



TECHNICAL NOTE 345

U.S. DEPARTMENT OF THE INTERIOR
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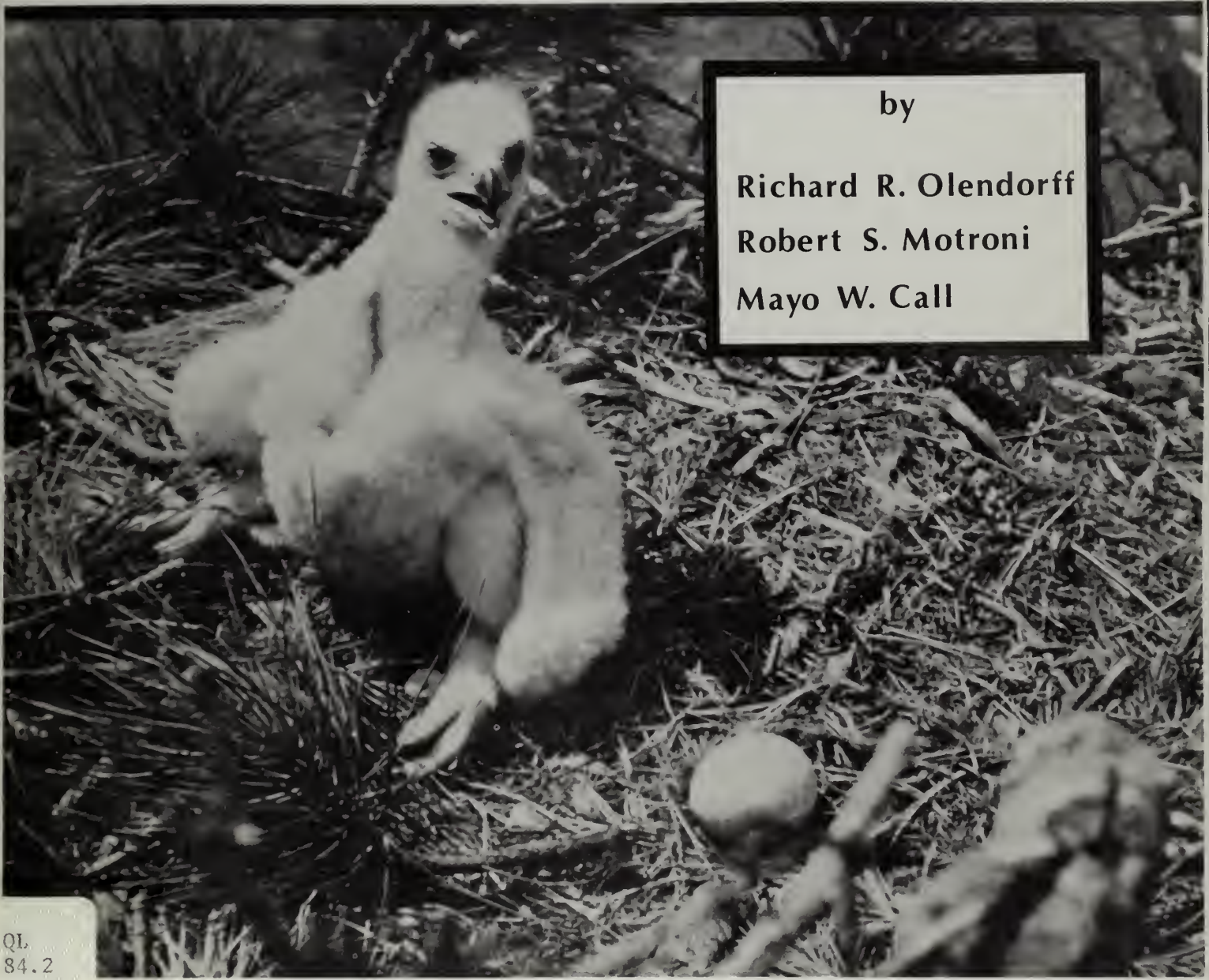
RAPTOR MANAGEMENT--THE STATE OF THE ART IN 1980

by

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ABSTRACT

The techniques of raptor management underwent a decade of intensive research during the 1970s. Raptor conservation, including species protection and management, as well as habitat protection and management, now receives unprecedented attention stemming generally from the increasing interest in nongame wildlife. Highlights of the 1970s include: 1) captive breeding (which is now routine) of 726 Peregrine Falcons at three major facilities in North America, plus smaller successes at other facilities and with dozens of other species worldwide; 2) proof of the value of egg manipulations (such as artificial incubation of thin-shelled eggs and double-clutching) in creating extra birds for management purposes; 3) the testing and evaluation of several methods of introducing extra birds to the wild, including clutch augmentation, fostering, cross-fostering, and hacking (controlled release of nestlings); 4) the establishment of numerous special areas to provide direct protection of key raptor habitats; and 5) the proliferation of raptor habitat management projects, including artificial feeding programs for raptors, provision of artificial perches and nesting structures, and the development of new natural nest sites. Success with many techniques during the 1970s exceeded most expectations. The 1980s should bring greater use of these techniques -- when and if (!) they are needed.

KEYWORDS: raptor management, raptor protection, captive breeding, egg manipulations, brood augmentation, fostering, cross-fostering, hacking, environmental assessment, special areas, habitat protection, land conversion, artificial feeding, artificial nest structures.

INTRODUCTION

1/

Earlier in this conference reference was made to Aldo Leopold's statement about saving all of the pieces being prerequisite to intelligent tinkering. Until recently, raptor biologists have in fact been trying merely to save all the pieces, so that they could someday have the opportunity to do some intelligent tinkering. We are happy to report that most of the pieces with hooked beaks and sharp talons have been saved, at least for the foreseeable future, and that a fair amount of tinkering is already underway.

This paper is an update on the state of the art of raptor management at the beginning of the 1980s. It also gives credit to those raptor biologists, conservationists, falconers, and other interested persons both on this continent and abroad who have collaborated in a diverse yet organized manner. We are given reason for optimism about the future of most raptor populations because of 1) the individual initiatives of the persons cited herein, 2) the organization provided by the International Council for Bird Preservation, Raptor Research Foundation, Hawk Mountain Sanctuary Association, and the National Wildlife Federation's Raptor Information Center, and 3) the specialized group efforts of the Peregrine Fund, North American Falconers' Association, Canadian Wildlife Service, Chihuahuan Desert Research Institute, Santa Cruz Predatory Bird Research Group, Hawk Trust, Southwest Hawk Watch, National Audubon Society, Eagle Valley Environmentalists, numerous federal, state, and provincial agencies, and many others.

Because of the interest of these groups and the recent information explosion concerning nongame wildlife (Murphy 1978), the concept of raptor management grew tremendously during the decade of the 1970s. This is indicated by the numbers and dates of publications reviewed for the present paper (Figure 1). When the pertinent literature was first reviewed in early 1973 (Olendorff and Stoddart 1974), fewer than 140 titles were available. During the last seven years about 435 titles have been added for a total approaching 600.

To review this literature, a thorough raptor management data base was created consisting of annotated bibliography cards, notecards in about 40 different subject categories, and the original papers. It includes primarily literature on 1) the impacts of man on raptor populations (except for pesticides and falconry, which may be added later) and 2) the management of wild populations (both habitat and species management, including such topics as captive breeding and rehabilitation, but only as they relate to release of birds to the wild). This data base is available for limited indirect use (brief phone and written inquiries), as well as direct use by appointment in Sacramento, California. Plans are being made for a computerized retrieval system to facilitate its use on a broader scale.

1/ Paper presented at the workshop on the Management of Western Forests and Grasslands for Nongame Birds, Salt Lake City, Utah, February 11-14, 1980. (Paper submitted April 17, 1980.)

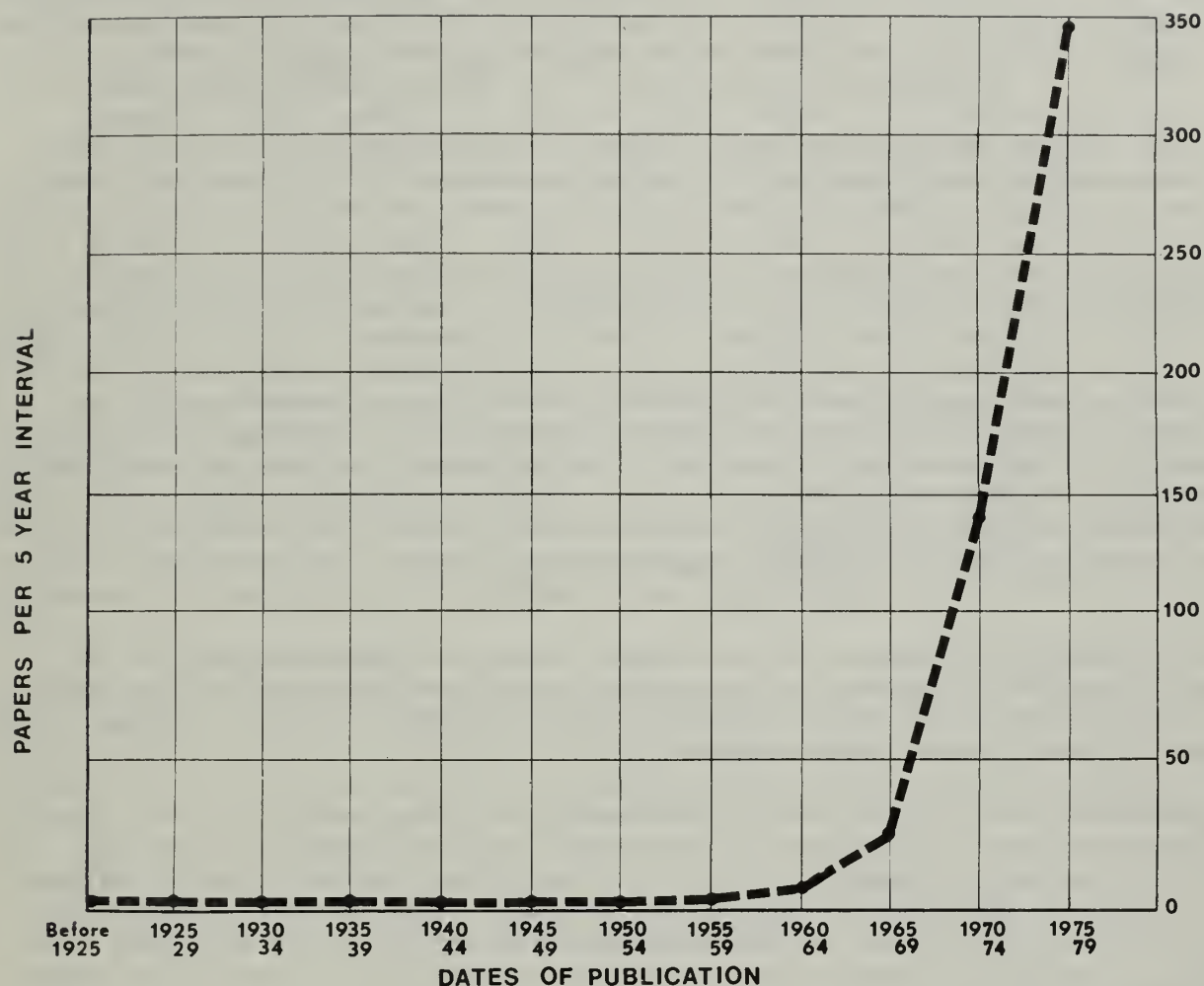


Figure 1.--The number of papers with direct raptor management implications published during each five-year period 1925-1979.

THE POTENTIAL FOR RAPTOR MANAGEMENT

The potential for management of raptor populations in western grasslands, which conceptually is much the same as in other habitats, has been summarized elsewhere (Olendorff and Stoddart 1974). This potential includes such things as the fact that different raptors use available nesting habitats differently; clumping of raptor nests where nest sites are abundant; use of man-made structures by raptors as nest substrates; the often low utilization of available prey resources; and the exploitation of large-scale, man-created changes in several key North American habitats. To this we can now add the success of recent raptor management research discussed elsewhere in this paper.

The exploitation by raptors of large-scale land conversions points out the opportunistic nature of some birds of prey and reminds us that far more raptor

management in this country has occurred inadvertently than has occurred purposefully--at least through the decade of the 1970s. Of particular note is the concentration around and extensive use of newly created reservoirs and dam outflows by Ospreys (Pandion haliaetus) and Bald Eagles (Haliaeetus leucocephalus) (e.g., Berger and Mueller 1969, Roberts 1969, Spencer 1976, Kennedy 1977b, Stumpf and Creighton 1977, Steenhof 1977, Henny 1977b, Henny et al. 1978a, 1978b). These species have reacted favorably to these changes and have pioneered the new habitats for nesting, feeding, and wintering. According to Lehman (1979), 70 percent of 95 Bald Eagle nest sites in California are associated with reservoirs.

Likewise with Ferruginous Hawks (Buteo regalis) and Swainson's Hawks (Buteo swainsoni) in the shortgrass prairie of northeastern Colorado (Olendorff and Stoddart 1974). In grasslands that were historically unbroken except by gallery forests and isolated springs, in 1970-1972, 44 of 45 Swainson's Hawk nest sites, 98 percent, were at abandoned farmsteads, ditches, windmills, or man-made ponds. Sixty-eight percent of the Ferruginous Hawks in historically unbroken grasslands were in man-created situations. A similar situation exists in parts of south-central Washington for Swainson's Hawks (Olendorff 1973), in the prairie provinces of Canada for Merlins (Falco columbarius) (Hodson 1976), and in the central United States for Mississippi Kites (Ictinia mississippiensis) (Parker 1975, Cranson 1975). Maser et al. (1979) discuss the value of man-made habitats to wildlife in general.

These examples do not mean that such large-scale, man-made changes were all good. To the contrary, what raptors gained, the ecosystem probably lost ten times over in ten different ways. These situations do hint, however, that purposeful management of these species may be possible.

Actually, "may be possible" is an understatement. The remainder of this paper deals with several major categories of the larger topic of raptor conservation. These include species and habitat protection (what we have learned from our efforts to save the pieces) and species and habitat management (what we have learned thus far by tinkering). Protection or "hands-off conservation" has been separated from management or "hands-on conservation," and species conservation is considered apart from habitat conservation. The most recent reviews of these topics are by Olendorff and Stoddart (1974), Cade (1974b), White (1974), and Snyder and Snyder (1975). Several conference proceedings are also germane: International Council on Bird Preservation (1964), Hickey (1969), Madsen (1973), Clement (1974), Hamerstrom et al. (1974), Ingram (1974, 1975, 1976), Ogden (1977), Temple (1978b), Chancellor (1977), Schaeffer and Ehlers (1978), Geer (1978), and Howard and Gore (1980).

SPECIES PROTECTION

Species protection includes the enactment of legislation, the promulgation of regulations, enforcement of these laws and regulations (including nest-site surveillance), and public education. The general legal status of raptors has been reviewed recently by Bond (1974), Hilton (1977), Conder (1977b), and Galushin (1977).

Three legislative or regulatory actions of the 1970s overshadow all others in importance to raptor protection. On March 10, 1972, the "Convention between the United States of America and the United Mexican States for the Protection of Migratory Birds and Game Animals" was expanded. This gave federal protection to all raptors under the Migratory Bird Treaty Act. Also in 1972, the use of DDT was banned in the United States, an action that was absolutely necessary to the survival of the Peregrine Falcon (Falco peregrinus), Bald Eagle, and Osprey. Almost two

years later, on December 28, 1973, Congress passed the Endangered Species Act of 1973, which has provided impetus--legal status as well as funding--to the endangered species conservation effort. The ramifications of these vital laws and regulations are felt almost daily by energy producers, land developers, the agricultural industry, and even individuals who interact with raptors in any way.

The enforcement of these laws and regulations, while there is room for improvement, is better than it has ever been. The National Wildlife Federation reward system (\$500) for those who report Bald Eagle shootings, has been used 13 times between 1971 and January, 1980. In 1976 alone, 33 eagles were shot and then reported to the U.S. Fish and Wildlife Service. Nine people were convicted, fined up to \$5,000, and given up to six months in jail (Schreiner and Senecal 1978).

One outgrowth of stepped up law enforcement is the Peregrine Falcon nest surveillance program in California, which has been directed by David L. Harlow (1977, 1978) and Douglas A. Boyce (1979) of the U.S. Fish and Wildlife Service. An eyrie warden program has been operating in Europe since about 1967 (Lindberg 1975, 1977). From 1967-1974, 19 Swedish eyries were given 24-hour surveillance. Twelve of these fledged young. In five eyries no eggs hatched; and two eyries were subjected to predation by mink or Eagle Owls (Bubo bubo).

In the United States, surveillance also started, though on a smaller scale, in 1967 and 1968 when Morro Rock, a prominent and well-publicized Peregrine eyrie on the California coast, was given 24-hour protection during the nesting season (McNulty 1972, Asrow 1977, Thelander 1978). This program was intermittent until Harlow took it over for the U.S. Fish and Wildlife Service in 1977. From 1977-1979 watches were maintained at 22 sites; 17 of these fledged young. Because of this comparatively high success rate at guarded eyries, the surveillance program is slated to continue into the 1980s.

SPECIES MANAGEMENT

Separate from species protection are two categories of species management: creating extra raptors for management purposes and introduction of extra birds to the wild. The numerous species management options involving captive breeding of raptors, introduction to the wild of eggs, young, and older birds, manipulation of wild populations, and the various combinations of these procedures are summarized in Figure 2. Processes shown nearest the center of the figure represent the captive regimen, while those around the periphery are natural (optimal) processes. At each major event in the life cycle (courtship, egg laying, hatching, fledging, and maturation) three major options are shown. Designs of nearly all pioneering and on-going raptor management research projects, as well as most conceivable avenues of future research on raptor species management, can be derived from this figure.

For example, in a hypothetical pair of captive adults, courtship (I--see Fig. 2) may be normal, but fertilization of eggs may be a problem. This can be solved by artificial insemination (IC) to get the laying of fertile eggs (II). It is now known that a period of incubation by either wild or captive adults (IIB) increases hatchability of artificially incubated (IIC) eggs. Artificial incubation may be desirable in order to double-clutch (recycle) the original pair. Once the eggs hatch (III) in the incubator, they might be hand reared (IIIC) until they are large downies at which time they could be fostered to a nest and reared by wild

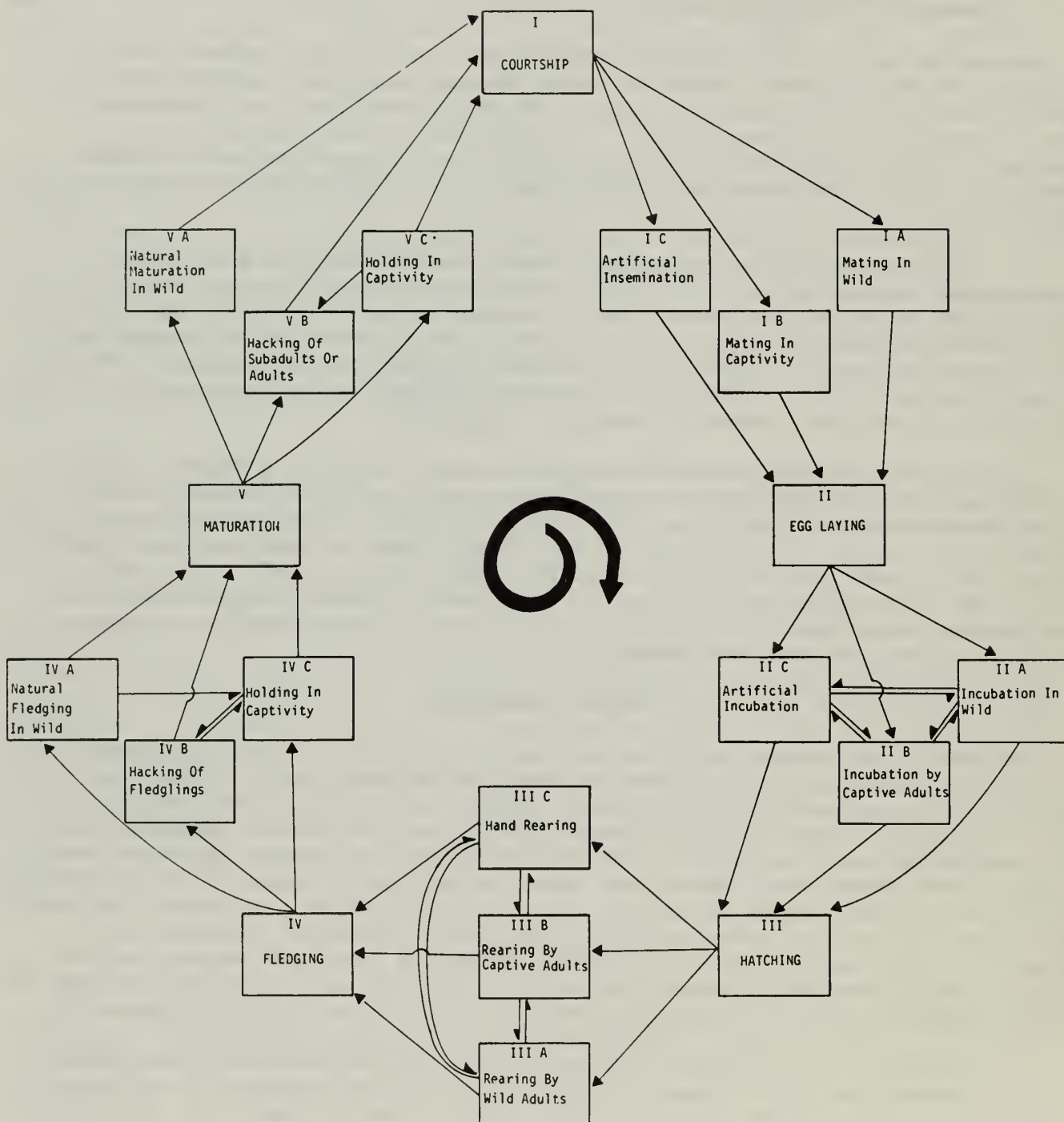


Figure 2.--Species management options involving captive breeding of raptors, introduction of birds to the wild, and manipulation of wild populations. See text.

adults (IIIA). Once fledged naturally in the wild (IVA) they would probably be allowed to mature in the wild (VA) and, hopefully, establish a wild pair that would court, lay eggs, and perform all the other processes of their life cycle in the wild. (Note the movement out from the center of the diagram to the outside toward more natural processes.)

Creating Extra Birds for Management Purposes

CAPTIVE BREEDING (IB or C-->IIB or C, etc.)

Captive breeding is of paramount importance in producing birds for management purposes. Admittedly, captive breeding is an expensive, labor intensive effort which can be justified on a large scale only for endangered species. In fact, only two raptors--the Peregrine Falcon and the American Kestrel (Falco sparverius)--are now bred in captivity in sufficient numbers to allow introductions to the wild with a reasonable expectation of subsequent breeding at or near the release sites. The emphasis on Peregrines is more a matter of priority and necessity than a lack of capability to do it with other species --given time and proper funding.

There are currently three major centers of Peregrine Falcon captive breeding in North America. The largest, at Cornell University, is run by Tom J. Cade, James D. Weaver, and Phyllis R. Dague, and is now producing about 100 Peregrines a year (Cade et al. 1977, Cade and Dague 1979). A total of 434 Peregrines have been raised since 1973 at this one facility (Cade and Dague 1978, 1979). A sister establishment, also part of the Cornell Program, which is financed through donations and grants to the Peregrine Fund, is at Fort Collins, Colorado. It is directed by William A. Burnham (1978, 1979). Another 111 Peregrines, mostly the rarest subspecies (Falco peregrinus anatum) have been produced there since 1975. The third facility, at Fort Wainright near Edmonton, Alberta, Canada, is run by Richard W. Fyfe for the Canadian Wildlife Service (Fyfe 1975, 1976). An additional 181 Peregrines have been captive bred at Fort Wainright through the 1979 season (Fyfe 1980 pers. comm.).

Two other large facilities are being developed. One is in Colorado Springs, Colorado, run by Richard A. Graham and the United Peregrine Society (Graham 1979). The other is in Santa Cruz, California, and is directed by Brian J. Walton through the University of California at Santa Cruz (Walton 1979a). Both of these facilities have shown initial successes in recent years and should produce even more birds in the future.

Those who operate these five facilities deserve a great deal of credit for the slowly improving status of the Peregrine in the continental United States, but much of their success is owed to many collaborators, especially many falconers who have donated birds, time, money, and expertise to the overall effort--the so called "back yard" raptor breeders.

The success with captive breeding of Peregrine Falcons, Gyrfalcons (Falco rusticolus), Prairie Falcons (Falco mexicanus), Merlins, and several species of hawks, eagles, kestrels, and owls has certainly provided the impetus to proceed with captive breeding of North America's most endangered raptor--the California Condor (Gymnogyps californianus) (Ricklefs 1978, Kiff 1979). About the only argument left for the purist who would have the California Condor "die on the vine" is the "death with dignity" scenario. However, it is apparent that the "right to life" group--including in this case the U.S. Fish and Wildlife Service, U.S. Forest Service, California Department of Fish and Game, U.S. Bureau of Land Management, American Ornithologists' Union, National Audubon Society, Raptor Research Foundation, and certainly others--have won out. Condors will be trapped for research and captive

breeding efforts beginning in 1980 or 1981 provided the necessary permits and other clearances can be obtained.

In summary, raptors can be bred in captivity; captive bred birds will breed with each other to produce F2 progeny--and surely F3 or F4 by now; and when two Peregrines are bred in captivity, they apparently are not inferior to wild birds. They are, more often than not, healthy, viable, young Peregrines, prime for introduction into the wild by one of several methods.

EGG MANIPULATIONS

Artificial Incubation of Damaged or Thin-shelled Eggs (IA-->IIC-->IIIA)

One symptom of pesticide-laden raptors is the laying of thin-shelled eggs. Perhaps the best example of "clinical ornithology," a concept set forth by David R. Zimmerman (1975) in his book "To Save a Bird in Peril," is if thin-shelled eggs can be removed from nests before they break, many of the embryos can be saved through extraordinary repair work and artificial incubation. This was first tried with Montagu's Harriers (Circus pygargus) in Britain (see discussion following Conder (1964)). Fyfe and Armbruster (1977) also have used this technique on a small scale with Peregrines.

Since 1977, William A. Burnham, in cooperation with Gerald R. Craig of the Colorado Division of Wildlife and James H. Enderson of Colorado College in Colorado Springs, has been rehabilitating thin-shelled Peregrine eggs brought in from the Rocky Mountain population (Burnham 1979, Burnham et al. 1978). Thus far, 87 fertile wild eggs have been patched, glued, partially covered with parafin, sanded, or just handled carefully before being placed in an incubator for hatching. Fifty-nine of these eggs have resulted in surviving young. A much smaller percentage would have hatched in the wild. In addition, many of these hatchlings have been returned to wild parents. In 1977 the productivity of the Rocky Mountain population was doubled (if not quadrupled) in this way (Cade 1978).

Double-clutching (IA-->IIC-->IIA or IIIA)

Some of the eggs which have been artificially incubated by Burnham (1979) were obtained through the convenient natural backup system now called double-clutching. It has been long and widely known that if eggs are removed early enough (optimum about seven to ten days with large falcons), adult raptors will recycle and lay a second clutch of eggs in about 14 days. Lejeune (1971) suggested that this mechanism be used as a raptor management tool.

Double-clutching has had an added benefit during the pesticide era. Two studies, one of Ospreys (Kennedy 1977a) in this country and another of Peregrines (Monneret 1974, 1978) in Europe, show that second clutches are more productive--presumably thicker shelled and with lower residue levels than first clutches.

Double-clutching can also be used to delay wild pairs 20 to 28 days to put them in synchrony with captive pairs from which foster young might come (Fyfe et al. 1978), or it can be used just to acquire birds for other management purposes (Walton 1979b). Problems include the fact that second clutches often have one less egg (Armbruster 1978, Fyfe et al. 1978); occasionally (10 to 15 percent of the time) the adults (particularly young adults) do not recycle (Armbruster 1978, Fyfe et al. 1978); and, where summer temperatures are high, a four-week delay in hatching may result in heat stress of young birds (Herbert and Herbert 1965, Boyce 1979).

Introduction of Extra Birds to the Wild

Ten years ago, critics were saying that Peregrine Falcons could not be bred in captivity in numbers sufficient to successfully introduce them into the wild. That criticism proved to be unfounded. Five years ago, critics were still saying that introduction to the wild would not work, particularly with any "inferior" Peregrines bred in captivity. Science has again demonstrated the limited vision of the critics. As with captive breeding, breakthroughs with introductions have involved Peregrine Falcons, but each proof of a point with Peregrines adds yet another possible tool to our management repertoire for other raptor species.

The techniques which are now being used to introduce raptors to the wild include clutch augmentation (adding eggs to wild nests), brood augmentation (more specifically fostering and cross-fostering additional young to wild parents), and hacking or controlled release of nestlings. Cade (1978) gives a brief review of introduction techniques as they have been used for endangered birds in general. Temple (1978c) elaborates specifically for birds of prey.

AUGMENTATION

The concept of augmentation is self-explanatory. If extra eggs or young birds are available, one can just place them in nests with other eggs or nestlings, provided they are at about the same stage of incubation or growth. This technique is particularly useful whenever clutch sizes or brood sizes are below normal in wild or captive populations.

Clutch Augmentation (IIA, B, or C-->IIIA)

The ease with which raptor eggs can be switched from one nest to another is perhaps best illustrated by Spitzer's (1978) work with Ospreys, although on-going efforts to save the Rocky Mountain Peregrine Falcon population (Burnham 1979) are also noteworthy. Recent studies of the timing and the extent to which clutch augmentation can be implemented have met with great success. For example, Fyfe et al. (1978) reported an estimated 100 egg swaps among their captive raptors with only two rejections.

In the wild, augmentation has been attempted even in excess of normal sizes of clutches and broods. This may be advisable under some circumstances (i.e. where food is not limiting). The Canadians (Armbruster 1978) have added eggs to wild Prairie Falcon and Peregrine nests to make clutches of six with total success, except for one infertile Prairie Falcon egg. Walton (1977) added extra Prairie Falcon eggs to two nests with complete success. Bennett (1974) reports on the switch of Bald Eagle eggs from Minnesota to Maine.

The usefulness of clutch augmentation has been proved. It is an easy, natural way to ensure that all nests in a population fledge an optimum number of young each year or to introduce captive-produced eggs into nests where wild parents will be available to feed and defend the young that hatch from them.

Brood Augmentation (IIIA, B, or C-->IIIA-->IVA)

Fostering. Data are available on the direct fostering of fourteen species of raptors (Table 1). The objectives of fostering have varied from case to case. Bald Eagles, Golden Eagles, Red-shouldered Hawks, Red-tailed Hawks, Ferruginous Hawks,

and American Kestrels have been fostered to other parents to save individual birds or broods after some calamity had befallen their original nest or else one of several in a brood had developed into a runt. Postupalsky (in Meyburg 1978) routinely rescued unusually stunted Osprey nestlings by switching them or their larger nest mates to other nests with success in 24 out of 25 instances. In testing the adequacy of Osprey food resources Spitzer (1978) moved 53 nestling Ospreys (3 to 30 days of age) from Maryland to Connecticut to create normal broods of two and three young. Forty-five of these young fledged successfully. In two cases adult pairs with two young 3 to 4 weeks old were given three new young only 1 week old without rejection problems. Fernandez (in Hamerstrom 1977) placed a chicken egg and later a young Osprey in the nest of a pair of Ospreys that failed to lay eggs. The egg was incubated, and the fostered nestling was reared.

Loss of young Spanish Imperial Eagles (an endangered species) from broods of four in which the last chicks to hatch do not survive has also been alleviated by fostering (Meyburg and Heydt 1973, Meyburg 1978). Fourteen chicks were transferred in one experiment, resulting in the saving of 30 percent of the eaglets hatched by nine pairs. The ultimate measure of success was a 43 percent increase in the number of young fledged by those pairs.

The fostering of Prairie Falcons has been done more as surrogate species management research than to bolster Prairie Falcon populations. The largest of these projects was conducted in Colorado by the Cornell group (Cade 1974a, Cade and Temple 1977). Fourteen young falcons were fostered to wild parents in 1974. One brood was augmented up to a total of seven nestlings. As far as is known, all of the 14 young fledged. Walton (1977) and Fyfe (1978) have fostered smaller numbers of Prairie Falcons in California and Alberta, respectively.

The most extensive fostering programs currently involve the Peregrine Falcon. Fostering Peregrines into the wild began in earnest in 1974 when the Canadian Wildlife Service began double-clutching and augmenting a declining Peregrine population in northern Alberta (Fyfe et al. 1978) and the Cornell group began doing the same in the Rocky Mountains (Burnham 1979). The Alberta population had been studied since 1970. It dropped to a low of three pairs in 1975, but increased to seven in 1977, including the reoccupancy of an eyrie that had not been used since 1966 (Fyfe et al. 1978). Currently the number of breeding pairs is about six or seven, but there are two or three new pairs with young adults which should breed in 1980 (Fyfe 1980 pers. comm.).

The first real breakthrough with any managed Peregrine population came in 1977 when a captive-bred bird from Fort Wainright, that had been fostered to wild parents on the Alberta study area in 1975, returned near its foster home to breed (Fyfe et al. 1978). To illustrate the compounding beneficial effects of these techniques, this bird was double-clutched in 1977. Six of her seven eggs were fertile, three of which she raised in the wild herself. In 1979 four marked birds were breeding in this population (Fyfe 1980 pers. comm.).

In the Rocky Mountain Region, 84 Peregrines have been introduced into the wild by direct fostering since 1974. Fifty-seven of these reached independence (Burnham 1979). Only one returnee has been verified (careful searches for bands were not made), but other one-year-old birds present at eyries in 1979 may prove to be the fostered young.

Table 1.--Species of raptors that have been fostered.

Species	Reference
Osprey	Fernandez (in Hamerstrom 1977) Postupalsky (in Meyburg 1978) Postupalsky 1978a Spitzer 1978
Bald Eagle	Postupalsky and Holt 1975
White-tailed Sea Eagle (<u>Haliaeetus albicilla</u>)	Fentzloff 1977, 1978 Helander 1976
Red-shouldered Hawk (<u>Buteo lineatus</u>)	Martin and Ruos 1976
Swainson's Hawk	Discussion following Hamerstrom 1974
Red-tailed Hawk (<u>Buteo jamaicensis</u>)	Postupalsky and Holt 1975
Ferruginous Hawk (<u>Buteo regalis</u>)	Olendorff and Stoddart 1974
Imperial Eagle (<u>Aquila heliaca</u>)	Meyburg 1978 Meyburg and Heydt 1973
Golden Eagle (<u>Aquila chrysaetos</u>)	Olendorff and Stoddart 1974
Booted Eagle (<u>Hieraaetus pennatus</u>)	Meyburg 1978 Meyburg and Heydt 1973
American Kestrel	Jones (in Byers 1980)
Prairie Falcon	Cade 1974a Cade and Temple 1977 Fyfe 1976, 1978 Granger 1977 Walton 1977
Peregrine Falcon	Armbruster 1978 Burnham 1979 Cade 1978 Cade and Dague 1977 Fyfe 1976, 1978 Walton 1979b
Eagle Owl	Broo 1977, 1978 Magnusson 1957 Wayre 1975

In summary, experiences with fostering allow considerable optimism. It is a relatively safe technique that has the invaluable advantage of the young being reared and fledged naturally by conspecific parents.

Cross-fostering. Fostering the young of one species to wild parents of another is one of two methods of introducing birds when no conspecific remnant population persists. The other is controlled release or hacking (see below). Ten different cross-fostering combinations are documented in Table 2. Three of these illustrate the current state of the art.

Table 2.--Cross-fostering combinations.

Fostered Species	Parent Species	Reference
Harris' Hawk (<u>Parabuteo unicinctus</u>)	Red-tailed Hawk	Stewart 1979
Common Buzzard	Northern Goshawk (<u>Accipiter gentilis</u>)	Stohn 1974
Ferruginous Hawk	Prairie Falcon	Fyfe et al. 1978
Lesser Spotted Eagle (<u>Aquila pomarina</u>)	Black Kite (<u>Milvus migrans</u>)	Meyburg 1971, 1977, 1978
Lesser Spotted Eagle	Common Buzzard (<u>Buteo buteo</u>)	Meyburg 1971, 1977, 1978
Prairie Falcon	Swainson's Hawk	Fyfe 1976 Fyfe et al. 1978
Prairie Falcon	Red-tailed Hawk	Fyfe 1976 Fyfe et al. 1978
Prairie Falcon	Ferruginous Hawk	Fyfe 1976 Fyfe et al. 1978
Prairie Falcon	Peregrine Falcon	Cade and Dague 1977
Peregrine Falcon	Prairie Falcon	Burnham 1979 Fyfe et al. 1978 Graham 1979 Konkel 1977 Spomer 1979

First, Meyburg (1971, 1977, 1978) has pioneered the technique of cross-fostering Lesser Spotted Eagles to Common Buzzard and Black Kite nests to circumvent the fratricide ("Cainism") that inevitably befalls the weaker eaglet in each nest. By cross-fostering one bird from each nest for several weeks until the Cain and Abel instincts diminish, and then returning the fostered bird to its original nest, Meyburg has nearly doubled the productivity at the manipulated nests (between 15 and 20 instances since 1968) (Meyburg 1978).

Second, Fyfe (1976) and Fyfe et al. (1978) have experimented extensively with cross-fostering Prairie Falcons to three species of buteos and, in one reverse case, Ferruginous Hawks to Prairie Falcons. In 1972 four of five captive bred Prairie Falcons were raised successfully by cliff nesting Ferruginous Hawks. In 1974, 16 young Prairie Falcons were put in three Red-tailed Hawk tree nests and one Swainson's Hawk tree nest in an area 130 km north of the normal range of Prairie Falcons. Two of these cross-fostered young were lost (one to a predator and one to a storm); the remainder fledged and dispersed at about the same time as wild Prairie Falcon young in the general area. Also of interest is the 1977 cross-fostering of 5 young Ferruginous Hawks to Prairie Falcons. All five hawks fell from the falcon eyrie at different ages.

The followup to this work is interesting, but it was still circumstantial in 1977 (Fyfe et al. 1978) when two new Prairie Falcon eyries were found on cliffs along the North Saskatchewan River, well north of the normal Prairie Falcon range and within 30 km of the area where the young were fostered to Red-tailed and Swainson's Hawks in 1974. Also of interest is the two-year occupancy of a Ferruginous hawk cliff nest by Prairie Falcons (the only such record known to the researchers) within 13 km of one cliff nest where Prairie Falcons were cross-fostered to Ferruginous Hawks in 1972.

The third type of cross-fostering experiment is part of the Peregrine Falcon recovery effort. Many historical Peregrine eyries are now occupied by Prairie Falcons (Nelson 1969b, Enderson 1969, Porter and White 1973). This provides an excellent opportunity for congeneric cross-fostering where Peregrines no longer exist.

The first serious cross-fostering of Peregrines to Prairie Falcons began in 1977 at the Snake River Birds of Prey Natural Area (Konkel 1977, Burnham 1977, Cade and Dague 1978). Three anatum Peregrines were cross-fostered that year with complete success. In 1978 five Peregrines were cross-fostered into two separate eyries. Two fledged successfully from one eyrie, but a combination of a bed bug infestation and owl predation caused complete failure at the other. In 1979 there was no success with cross-fostering at the Snake River Birds of Prey Natural Area (Burnham 1979). Three Peregrines were put in one Prairie Falcon eyrie: two were lost in a nighttime wind storm; the other was struck by a neighboring Prairie Falcon.

Other attempts to cross-foster Peregrines to Prairie Falcons were made by the Cornell group in 1979 in South Dakota (3 birds) (Spomer 1979), Nebraska (3 birds), and Colorado (6 birds) (Burnham 1979). An additional attempt by Graham (1979) in Colorado involved two birds. Of these 14 birds, only six reached independence due to avian predation (Golden Eagles and, perhaps, Great Horned Owls (Bubo virginianus)) and diseases (pneumonia and a sporozoan disease similar to malaria).

Thus, the optimism which followed the successful cross-fostering in Idaho in 1977 has given way to a more cautious approach of using this technique only where other methods are unavailable. Even controlled release (i.e. hacking) in the

absence of protective parents has been more successful than cross-fostering (see below). As a result, cross-fostering of Peregrines to Prairie Falcons apparently will be deemphasized during the next few years (Burnham 1979), not so much because it will not work, but, again, as a matter of priority. It is a better investment of young Peregrines to augment existing populations rather than step out into areas of historical occupancy. It is a simple numbers game. An estimated 60 young Peregrines released over a two- or three-year period would be needed to establish a marginally viable isolated population of three pairs (Burnham 1979). When more young Peregrines are available, perhaps cross-fostering in unoccupied historical habitat will be more cost effective--in dollars and in falcons.

HACKING

The technique of removing young raptors from their nests and fledging them from some artificial structure or nest was developed by falconers to provide their birds with a degree of natural experience before being taken into captivity for falconry training (Michell 1900, Blaine 1936, Mavrogordato 1966). By supplying food to the birds for a longer period of time--until they are capable of killing for themselves--they can gradually be returned completely to the wild in a predetermined place.

The hacking of raptors as a species management technique is limited almost exclusively to the 1970s. A few exceptions follow. Wayre (1970, 1975) released young Barn Owls (Tyto alba) and Little Owls (Athene noctua) by feeding them each night on top of their parents' aviaries during the late 1960s. Swedish ornithologists have been breeding Eagle Owls in captivity and releasing the young by several hacking techniques since the mid-1950s (Magnusson 1957; Wayre 1970, 1975; Broo 1977, 1978). An unsuccessful attempt to hack White-tailed Sea Eagles on the Isle of Rhum occurred in 1968 (Everett 1978), although Love and Ball (1979) are having better luck with the same species in the same area. Twenty-four eagles have been released successfully since 1975.

Bald Eagles were hacked successfully in 1976 and 1977 (Milburn 1977; Cade and Dague 1976, 1977) at the Montezuma National Wildlife Refuge in New York. One of the two birds released the first year returned to the refuge in August of 1977, thirteen months after being released and ten months after dispersing. Five more eaglets were hacked successfully in 1977.

During the spring and fall of 1979, an attempt to hack fourteen Harris' Hawks of varying ages and captive histories was made along the Lower Colorado River where this species had been extirpated (Stewart 1979, Gallagher 1980). There has been an apparent increase in the number of Harris' Hawk sightings in the general area (several in September 1979) (Conrad 1979b, Gallagher 1980). This work continued during the spring of 1980 with the release of a pair that had previously bred in captivity (Walton 1980 pers. comm.). Within one month the pair built a nest and laid eggs. Two aspects of this release are particularly noteworthy. First, the birds were taken from the wild as eyasses. They had no previous experience in the wild. Second, they nested within 100 yards of the point of release. Mature birds released into the wild generally disappear and are never seen again.

All other hacking projects mentioned in the literature reviewed for this paper involve the Peregrine Falcon recovery effort. This includes preliminary work with Prairie Falcons as a surrogate species. Three Prairie Falcons were hacked in New Mexico in 1974 (Cade 1974a), and six more were hacked at the Colorado State Prison at Canon City in 1975. All nine birds fledged successfully.

The largest hacking program has been conducted with Peregrine Falcons by the Cornell group in the eastern United States where the Peregrine was extirpated during the early 1960s. The pioneering attempt was made by Heinz Meng from atop the 10-story high Faculty Tower on the New York State University College campus in New Paltz (Meng 1974, Meng and Kaufman 1975, Kaufman and Meng 1975, Cade 1974a). Two birds bred in captivity at Cornell were placed at the hacking site in New Paltz one week before being able to fly. Both fledged successfully. However, one was killed a short time later, apparently by someone who did not care to have pigeon-killing birds in an urban environment. The second bird was never seen after it dispersed.

In 1975 sixteen Peregrines were hacked at five sites in Maryland, New York, Massachusetts, and New Jersey (see Cade 1978 or Sherrod and Cade 1978 for details about techniques). Twelve of these birds fledged, and five (42 percent) returned to hack sites in 1976 (Cade and Dague 1976). The first pair formation occurred in 1978 at Sedge Island, New Jersey (Cade and Dague 1978), where a male released in 1975 had been returning every year since 1976. Ten or 11 adult or subadult Peregrines returned to eight different hack sites in 1978.

By 1979 success began interfering with further introductions at some hack sites (Cade and Dague 1979). A total of 211 Peregrines were hacked into the wild in the eastern States between 1974 and 1979. Of these, 150 (or 71 percent) reached independence. Returnees in 1979 included: 1) a single female that laid infertile eggs (the first in 20 years in the East) on a building in Baltimore and subsequently raised two foster young by herself; 2) pairs at all three hacking towers in New Jersey (one of which produced fertile eggs that were later destroyed by crows); and 3) eight individuals at other sites in the east for a total of 15 (i.e. 10 percent of those successfully hacked and 14 percent of those that dispersed from the hacking stations between 1974 and 1978).. Successful breeding should occur in 1980.

Hacking of Peregrines began in the Rocky Mountains in 1978 (Burnham 1978). At one site in New Mexico four birds were hacked into a territory of a wild pair that had failed. When the young birds flew, they were attacked by the resident adults and therefore were removed from the site. The other 1978 attempt was in Rocky Mountain National Park. Five birds were hacked; all reached independence. One returned to the site in 1979 (Burnham 1979) while five more young were being released there. In all, 24 Peregrines have been hacked in the Rocky Mountains (New Mexico, Colorado, and Utah). Nineteen of these (79 percent) have reached independence.

It is difficult to portray the excitement of these successes in words. Again, the techniques are working, and the birds apparently are not inferior to non-introduced Peregrines. One male returnee called the "Red Baron" is exemplary. He was observed chasing prey 93 times in 1979, and he was successful 90 of them (Cade and Dague 1979). At one stretch he made 60 consecutive kills. Tom Cade put it nicely in the 1979 Peregrine Fund Newsletter, and he more than any other person should be the judge:

When I watch this magnificent tiercel hunt, I am reminded of another time and place, 5,000 miles away on the Yukon River where I have seen the wild relatives of this very falcon make similar hunts after winnowing snipe high over the boreal forest. What has been said of the California condor may have meaning in some poetical sense; but for these falcons, I tell you truly, I cannot see a difference with my eyes, nor do I feel a difference in my heart, which pounds against my chest with the same vicarious excitement when the Red Baron stoops over the New Jersey salt marshes, as it did in 1951 when I first saw this high flying style of hunting performed by the wilderness inhabiting peregrines of Alaska.

HABITAT PROTECTION

Habitat protection is accomplished primarily by making land managers and the general public more aware of raptor habitats and by controlling the use and development of raptor habitats wherever necessary and possible. This can be done in many ways, including: 1) enactment of legislation and enforcement of related regulations (many of which are for other purposes, e.g., wilderness legislation, air and water quality standards, etc.); 2) land-use planning, 3) environmental assessment; 4) creation and designation of special areas; and 5) public education.

The ultimate in habitat protection would be "to set aside as nature reserves at least one big area of each...self-supporting or closed ecosystem where birds of prey occur in large numbers and species and to intensify the conservation of these birds because they are still plentiful" (Voous 1977). We may see this happen in the decade of the Eighties or Nineties, but it is not now politically feasible. We must, therefore, rely on a combination of the other available techniques.

Legislation

The most important legislation concerning habitat protection and management on federally administered lands was reviewed briefly by Olendorff and Zeedyk (1978). The Critical Habitat provisions of the Endangered Species Act of 1973 (as amended) are particularly noteworthy (Porter and Marshall 1977, Wilbur 1978). The current regulations concerning Critical Habitat are published in Parts 17, 402, and 424 of Chapter IV of Title 50 of the U.S. Code of Federal Regulations (see Federal Register 45(40): 13010-13026, February 27, 1980, for the most recent release).

Designation of Critical Habitats is a controversial issue in that it discloses sensitive eyrie information, an act in itself which could jeopardize the continued existence of particular pairs of endangered birds. Thus, in California where five Critical Habitats have been officially designated for the Peregrine Falcon, the active, published eyrie sites are watched throughout the nesting season on a 24-hour, 7-day-per-week basis (Harlow 1977, 1978; Boyce 1979). The nine California Condor Critical Habitat Zones are not watched as closely, but all land management actions which may adversely impact these areas are reviewed through the Endangered Species Act consultation processes.

The only other federally determined Critical Habitat for an endangered raptor is for the Everglade Kite (Rostrhamus sociabilis) in Florida. However, the State of Alaska has implemented its own Critical Habitat legislation on a smaller scale, principally to protect a stretch of the Chilkat River which in some winters supports 3,000-3,500 Bald Eagles (Snow 1973).

Less specific but still very germane to raptor conservation are the multiple-use, sustained-yield mandates under which the major land managing agencies operate (e.g., U.S. Bureau of Land Management and U.S. Forest Service) (Olendorff and Zeedyk 1978). These laws establish broad guidelines for inventory, research, land-use planning, and environmental assessment, all of which have aided raptor conservation. An analysis of Federal Government involvement (United States and Canada) in the subject matter and/or authorship of the papers cited herein indicates that 50-60 percent of the raptor programs in North America are federally supported, primarily as a result of new laws passed in the 1970s. Some of the more significant of the land-use laws include the Sikes Act as amended in 1974, Resources Planning Act of 1974, National Forest Management Act of 1976, and the Federal Land Policy and Management Act of 1976.

Land-use Planning

The most intensive land-use planning to benefit raptors must certainly be for the 100 nesting pairs of Bald Eagles on or near the Chippewa National Forest in north-central Minnesota (Mathisen et al. 1977, Mathisen 1978). Each territory is described in a management plan based on a field examination of the nest location, nest tree characteristics, special threats to the territory, and surrounding habitat. Photographs and maps add to the visual record of the territory. A narrative is then prepared consisting of six elements: description of the territory, nest site characteristics, pair behavior, nesting history, additional research data, and management constraints.

The management constraints apply to several concentric buffer zones around the nests including the following: 330-foot zone (100 meters)--no activity; 660-foot zone (200 meters)--no activity from February 15 to October 1, and very little activity the rest of the year; and 1,320-foot zone (400 meters)--no activity from February 15 to October 1, but no restrictions on activities the rest of the year. The 1,320-foot zone can be extended an additional 1,320 feet if justified in the management plan.

Buffer zones to protect raptors have been prescribed in U.S. Forest Service land-use plans since 1963 (Mathisen 1968). The most common approach in the western United States has been to designate circular primary and secondary management zones, activities being more restricted in the primary zones (U.S. Forest Service 1977, U.S. Fish and Wildlife Service 1977). Now, however, more information is allowing the delineation of irregular zones based on topography, foraging patterns, the limits of territoriality or defense behavior, and even the distribution of trees which themselves can buffer the birds from disturbance. The work by Stalmaster (1976) and Stalmaster and Newman (1978) on Bald Eagle habitat utilization and recommended buffer zones is particularly useful. Other Bald Eagle buffer zones are recommended by Coffey (1977) and Steenhof (1977), and Helander (1977) gives recommendations for the closely related White-tailed Sea Eagle.

Buffer zone recommendations are also available for other species: Osprey--Roberts (1969, 1970), Kahl (1972b), Kahl and Garber (1971), Radtke (1973), Garber et al. (1974), Gale and Forkis (1974), Zarn (1974a); California Condor--Wilbur (1978a), Sibley (1969); Peregrine Falcon--Haugh and Halperin (1976), Monk (1979), Ellis (1978), and Enderson and Kirven (1979); Accipiters--Tankersley (1976), Luckett (1977), and Jones (1979); and Spotted Owl (Strix occidentalis)--Zarn (1974b) and Gould (1974).

A similar nest territory plan program is currently in effect for all Bald Eagle territories in California. Seventy plans are in various stages of development and approval, an effort which is coordinated by the California Bald Eagle Working Team. The prototype Peregrine Falcon nest territory plan is currently being developed by the California Peregrine Falcon Working Team.

Land-use planning on a broader scale can also protect raptor habitats. The U.S. Bureau of Land Management planning system provides a useful example (Olendorff and Kochert 1977). The Bureau has divided its land into about 650 geographic units on which land-use plans are made. Raptor habitats are routinely identified during the planning process in most units, particularly in the preparation of a document called the Management Situation Analysis (formerly the Unit Resource Analysis).

This analysis also contains data on general wildlife habitat conditions and land management potentials, as well as on all other resources. These data are correlated in the final document using tables, map overlays, and narratives explaining each resource. Habitat inventories for birds of prey yield input into these planning analyses.

The results of U.S. Bureau of Land Management surveys of raptor habitats often include maps of important raptor areas, base-line data for establishing raptor population trend studies, and detailed narratives concerning the biological as well as the aesthetic values of raptors. Such information is later used to develop a second document called the Resource Management Plan. This long-range plan provides a framework of multi-use coordination among the various resource program activities. It establishes objectives and constraints for each resource, including wildlife. For example, in Idaho much of the management of the Snake River Birds of Prey Natural Area is supported by Resource Management Plan recommendations.

Another planning mechanism provides a firm basis for short-term, on-the-ground enhancement of wildlife habitat. To ensure proper planning of enhancement projects, Habitat Management Plans are written by the Bureau of Land Management wildlife staff. The Bureau currently has nearly 200 of these site-specific plans in various stages of preparation and implementation in the contiguous Western States. Several of the 200 have direct raptor habitat management implications.

Most other federal and state agencies also have planning systems that benefit raptors, at least to the extent that other wildlife resources are benefitted. This aspect of wildlife conservation is too frequently overlooked by non-agency wildlife advocates, when, in fact, it may be the only way to effect meaningful protection.

Environmental Assessment

Knowledge of many raptor populations increased exponentially during the 1970s due, in large part, to the requirements of the National Environmental Policy Act of 1969 and the Endangered Species Act of 1973. Virtually every Federal action requires at least an environmental assessment. Hundreds of these documents are prepared each year, and many require raptor inventory data. Some larger or more controversial actions require a full environmental impact statement (Olendorff and Kochert 1977; Fyfe and Armbruster 1977). The value of raptor data gathered for these statements is grossly underrated because it usually is not published. Public input is an important component of this process that should be used to the fullest extent possible.

Designation of Special Areas

The need for designation of special areas where raptors can breed and winter relatively free of disturbance was reflected in resolutions passed at the 1975 World Conference on Birds of Prey in Vienna, Austria (Chancellor 1977). The conferees urged "national conservation bodies and governments to set aside sufficient representative nature reserves where birds of prey live in large variety and abundance and to conserve these birds while they are still plentiful." We are making progress in the United States toward such a goal by setting aside National Wildlife Refuges, natural areas, raptor management areas, and sanctuaries. In addition, wilderness areas, wild and scenic rivers, National Parks, and National Monuments provide de facto protection for many raptors (Murphy 1978).

NATIONAL WILDLIFE REFUGES

Several National Wildlife Refuges were newly created in the 1970s specifically for endangered raptors, including four for the Bald Eagle in Maine, Oregon, Virginia (Deane 1966, 1967, 1968), and South Dakota (Graham 1976, Anonymous 1974, Nesbitt 1975); one for the California Condor; and one for the Peregrine Falcon in New Hampshire (a bit late!). Certain other refuges have active raptor management programs, including the Glen L. Martin near Chesapeake Bay with its Osprey nesting platforms (Rhodes 1972, 1977); Brigantine, one of the Peregrine Falcon hacking sites (Cade and Dague 1976); and Montezuma, a hack site for Bald Eagles (Milburn 1977, Cade and Dague 1976, 1977).

NATURAL AREAS

Two areas called natural areas were established in the 1970s. The Skagit River Bald Eagle Natural Area was dedicated by Washington Governor Daniel Evans on February 6, 1976 (Margolis 1974, Beebe 1976, Davis 1976). The effort and cost expended by the Nature Conservancy and other cooperators to get this and similar areas set up provides detailed lessons in the use of techniques such as land acquisitions, conservation easements, land exchanges, and land withdrawals to promote raptor habitat protection. The result in this case is a continuous seven-mile corridor of vital eagle habitat (Servheen 1975) along the Skagit River which is now controlled by the Nature Conservancy and the Washington Department of Game.

The largest and most publicized natural area designed for raptor habitat protection is the Snake River Birds of Prey Natural Area administered by the U.S. Bureau of Land Management (Chaney 1979; Meiners 1971; U.S. Bureau of Land Management 1975, 1976, 1977; Zwinger 1977; Haley 1978). Through the early initiative of U.S. Bureau of Land Management employees, such as Bill Meiners and Edward Booker, and raptor expert Morlan Nelson, this 26,300-acre natural area was created in 1971 (Dunstan 1979b). Since then, under the principal leadership of Michael Kochert and with excellent support from the Bureau of Land Management Boise District Manager Dean Bibbes, an extensive research program has justified the creation of a larger 515,000-acre National Conservation Area (U.S. Bureau of Land Management 1979), including the foraging habitat of the birds. The proposal is now in the hands of the Secretary of the Interior and is awaiting introduction to Congress. In this one case Voous' (1977) objective of setting aside self-supporting ecosystems where birds of prey are still abundant is being met.

MANAGEMENT AREAS

Designation of important raptor habitat as management areas seems to carry less legal backing than the other special areas discussed above, but the management area concept is still a valuable tool. Three such management areas were designated--all by the U.S. Forest Service--during the late 1960s and early 1970s.

The Seymour Eagle Management Area for Bald Eagles in Southeastern Alaska includes several small islands in Seymour Canal on Admiralty Island (Robards and Taylor no date; Robards and Hodges 1977). Fishing and camping are still allowed in the area, but commercial development is severely limited. About 85 Bald Eagle nesting territories are found within the boundaries of the area.

The other two management areas are for Ospreys--at Crane Prairie Reservoir in Oregon (Roberts 1969, 1970) and at Eagle Lake in northern California (Kahl 1971; Kahl and Garber 1971; Kahl 1972a, 1972b; Garber et al. 1974). Crane Prairie Reservoir was created in 1922 on the Upper Deschutes River for irrigation purposes. The

reservoir was flooded without clearing the timber. Thus, in a few years the ponderosa pine snags became prime habitat for about 35 pairs of nesting Ospreys. A few of the restrictions in effect at this reservoir include no cutting in a 200-foot-wide strip immediately adjacent to the reservoir; restricted cutting for the next 1,120 feet away from the reservoir where at least two dominant trees per acre must be left; a 132-foot-wide "no-cut" buffer zone around each nest; a "restricted activity" zone 660 feet on all sides of the nest; and no hunting from April 1 to September 30 each year. Management programs include signing of nest trees and erection of artificial nest sites as needed to replace downed snags.

SANCTUARIES

Today the term "sanctuary" is more often applied to special areas privately owned by individuals or organizations. Two exceptions are the California Condor sanctuaries on the Los Padres National Forest just north of Los Angeles (Wilbur 1978a, Mallette and Schlorff 1978) which have existed for several decades. The 1,200-acre Sisquoc Condor Sanctuary was established in 1937, while the 53,000-acre Sespe Condor Sanctuary was designated in 1947. Both are essentially closed to public use.

The most famous raptor sanctuary in North America is Hawk Mountain Sanctuary established in the mid-1930s near Dreherstown, Pennsylvania, where thousands of people enjoy hawk watching each fall during the eastern migration (Collins 1935, Edge 1936, Broun 1949, Brett and Nagy 1973, Harwood 1973, Heintzelman 1975, Nagy 1978a). Another example is the Children's Bald Eagle Nesting Area in Minnesota, bought by Hunt and Wesson after children turned in about a million and a half bean can labels. The four sites purchased, totaling about 114 acres, were later turned over to the Chippewa National Forest for management (Mathisen 1973).

In a similar case, the Illinois Audubon Society's "Dimes for Eagles" program in the public schools helped the Nature Conservancy purchase 580 acres of Bald Eagle winter habitat along the Mississippi River which housed 454 Bald Eagles during the National Wildlife Federation's 1979 mid-winter Bald Eagle survey (Dunstan 1979a). Part of this area is known as the Children's Eagle Refuge. An excellent symposium on preservation and acquisition of Bald Eagle habitat was conducted in 1975 (Ingram 1975).

The National Audubon Society has three sanctuaries which emphasize raptor habitat protection (Graham 1978). The Okeechobee and Observation Shoal Sanctuaries (28,250 acres combined) contain the best breeding habitat for the endangered Everglade Kite. Some of the finest shortgrass prairie raptor habitats occur on the 14,800-acre Eagle Rock Audubon Sanctuary in northeastern Colorado which is private land leased from Mark T. Cox III of Cheyenne, Wyoming.

HABITAT MANAGEMENT

Habitat management generally involves some physical change or development of an area to make it more suited to the needs of one or more species (Call 1979). Protection of raptor populations in naturally diverse and relatively undisturbed habitats (discussed in the previous section) does not as a rule require habitat management. However, habitat management is frequently necessary and justifiable 1) in developing larger raptor populations where some crucial habitat requirement is lacking (e.g., where prey resources are adequate, but no nest sites exist); 2) in mitigating the impacts of agricultural, industrial, urban, recreational, and other

land uses on raptor habitats; and 3) in reclaiming habitats following extensive degradation caused by mining, off-road vehicle abuse, livestock grazing (especially in riparian areas), or any other surface disturbing activity.

Nearly all past and present raptor habitat management projects can be categorized as follows: 1) manipulation of prey populations; 2) manipulation of vegetation; 3) artificial feeding; 4) management of perches; and 5) provision of artificial nests and nesting structures. The decade of the 1970s was a period of considerable uncoordinated "small-time" experimentation with raptor habitat management, but very little research with sound experimental design was conducted. Only the development of artificial nestboxes for kestrels and small owls and of artificial platforms for Ospreys now produce predictable desired results.

Management of Prey Resources

Management of prey resources includes direct manipulation of prey populations; manipulations of plant composition, density, and structure (and thereby prey numbers) to benefit raptors; artificial feeding of raptors; and management of perches to facilitate raptor feeding.

MANIPULATION OF PREY POPULATIONS

The state of the art of managing prey populations to benefit raptors is not well advanced, although we have learned a great deal inadvertently or as a by-product of other management. For example, on the Shasta-Trinity National Forest, Bogener (1979) found that Ospreys which nest within 1.5 miles of fish stocking sites produce more young than those that nest further away. Also, there is considerable literature on the opportunistic nature of birds of prey in taking advantage of abundant prey resources--both short-term and long-term--no matter how the excesses may have developed. The converse is also true; a long-term decrease in prey resources usually causes a long-term decrease in raptor populations. Hodson (1976), for example, attributes the decrease of nesting Merlins in parts of Canada to a decrease in prey availability caused by the conversion of native grassland (which supported adequate passerine populations) to agriculture (which supports far fewer passerines).

Most recommendations concerning direct management of raptor prey populations are for Bald Eagles (Radtke 1973, Beebe 1976, Steenhof 1977, Conrad 1979a). These include 1) maintenance and restoration of natural runs of anadromous fish; 2) stocking of fish where they would be vulnerable to Bald Eagle predation (sloughs, backwaters, small impoundments); 3) allowing commercial and recreational fishing only to the extent that it does not interfere with effective predation by Bald Eagles; 4) manipulating water levels in reservoirs to facilitate eagle predation; 5) discouraging stream channelization; and 6) promoting habitat improvement projects for upland game and waterfowl.

Some of these recommendations follow from field observations. Spencer (1976) reports an increase in wintering Bald Eagles on the Monte Vista National Wildlife Refuge in Colorado to over 200 birds following waterfowl habitat improvements. McClelland (1973) documented tremendous increases in Bald Eagle use of Glacier National Park following the establishment of a Kokanee salmon run in the park. Spencer (1976) cites similar examples in Colorado, Oregon, California, Idaho, and New Mexico.

Schnell (1979) recommends the installation of low cross dams along streams in Common Black Hawk (Buteogallus anthracinus) habitat to concentrate fish and frogs near nest sites.

MANIPULATION OF VEGETATION

In general, it is not financially feasible to manipulate vegetation on a large scale solely to increase raptor prey populations. It is more realistic to gain concessions for raptors as part of other ongoing management. For example, range management practices that maintain ranges in good condition will provide an adequate prey base for many raptorial species (Craighead and Craighead 1956). Olendorff and Stoddart (1974) indicate that the largest, most closely controlled private ranches in northeastern Colorado are the best habitat for most resident raptors. While this relates to minimizing human disturbance at nests, it also indicates an adequate prey base.

The primary effect of livestock grazing on raptors is an indirect influence produced by changes in vegetation composition, density, and structure. These changes in cover and shelter for wildlife produce concurrent changes in small mammal, bird, reptile, and amphibian populations. Lower vegetation with lesser density tends to make small rodents and lagomorphs more vulnerable to predation. Thus, moderate to heavy livestock grazing of sagebrush (outside of riparian areas!) for several consecutive years in winter may cause the death of many of the plants, open up the area, and thereby facilitate raptor predation during the ensuing summers.

By knowing the specific prey requirements of the various raptors, land managers can benefit particular species of raptors through different kinds of vegetation conversion projects. Where possible, brushland habitats and grasslands should be retained in a random arrangement--a mosaic--within the planned vegetation treatment area. Another alternative is the scatter pattern of exclosures suggested by Hamerstrom et al. (1957) for Prairie Chickens (Tympanuchus cupido). The concept of "edges" and their beneficial effects on animal species diversity (see Thomas et al. 1979 for a recent review) should also be incorporated into any land conversion project designed to increase prey populations for raptors. Large monocultures of crested wheatgrass, for example, should be broken into smaller units interspersed with at least 20 percent native plant communities (Howard 1975, Howard and Wolfe 1976).

Removal of juniper from native sagebrush/grassland habitats followed by effective reseeding has been shown to increase small rodent (primarily mouse) populations for at least two years following treatment (Baker and Frischnecht 1973). In addition, Westoby and Wagner (1973) found that jackrabbit numbers are generally higher in desert shrub vegetation near edges with grassland. Howard and Wolfe (1976) infer that these findings could be applied in future land conversion projects to benefit Ferruginous Hawks.

Everett (1978) suggests that habitat management for the Marsh Harrier (Circus aeruginosus) could be extremely beneficial. This would involve purposeful reintroduction of reedbeds on a large scale.

ARTIFICIAL FEEDING

Artificial feeding of raptors at winter concentration areas is done for several reasons: 1) to ensure that food sources are available at all times, especially during bad weather, 2) to offer a pesticide-free diet to contaminated raptor populations exhibiting poor reproductive success; 3) to reduce the probability that vultures will feed on poisoned baits; and 4) to augment food supply during the breeding season. Such programs are recommended only for endangered raptors and only when food resources are inadequate or contaminated (Archibald 1978).

The major artificial feeding programs are for White-tailed Sea Eagles (Helander 1978), various Old World vultures (Biljeveld 1974, Zimmerman 1975, Archibald 1978, Iribarren 1977, Schenk 1977), and the California Condor (Wilbur et al. 1974; Wilbur 1978a, 1978b). Artificial feeding of Ospreys was conducted from 1966-1972 in southern New Jersey by Herbert H. Mills (Graham 1973, Mills 1977). Dead menhaden (up to three per day) were placed near frequently used perches and were usually taken by the birds as soon as Mills left the perch area. Beebe (1976), Steenhof (1977), and Detrich (1978a) recommend artificial feeding for Bald Eagles, but to date no such programs have been implemented for this species. Bergman (1977) reports artificial feeding of Golden Eagles in Finland.

Sweden's White-tailed Sea Eagle artificial feeding program is the largest of its type (Helander 1978). Over 100 tons of food are put out each year at nearly 100 stations. The objective is to supply the eagles with pesticide-free food, including primarily slaughterhouse offal and whole animals obtained on an opportunistic basis (e.g., roadkills and dead domestic stock). While the number of immature White-tailed Sea Eagles at feeding stations has increased since 1971 (possibly through a learned behavior), an increase in productivity on the nesting grounds has not been noted.

The California Condor artificial feeding program has shown similar results; condors use the stations, but no increase in breeding has occurred since the program's inception in 1971. However, artificial feeding of condors may be serving another purpose. In recent years, the remaining birds have been congregating further and further away from nesting areas. The feeding stations are near the breeding areas and may be functioning to preserve traditional ties to nesting areas on the Sisquoc and Sespe Condor Sanctuaries. Nonetheless, this program is not without critics (e.g., McMillan 1965).

The problems of European and Middle Eastern Griffon Vultures (Gyps fulvus) involve an overall shortage of food and the widespread use of pesticides. A breeding colony of three pairs established itself about 1 km from a Griffon Vulture feeding station in Israel (Mendelssohn in Archibald 1978). Other vulture restaurants include two in Sardinia and six in Spain.

The feasibility of artificial feeding programs for non-carrion-eating raptors has been shown in many ways. Raptors are easily trapped using live baits for research and falconry purposes. A large portion of the Spanish Peregrine Falcon population exists on artificial food provided by the hundreds of dove-cotes scattered across the country. Artificial feeding of young Peregrines is an integral part of the Peregrine introduction efforts (e.g., Sherrod and Cade 1978). Felton (in Thelander 1978) provided live pheasants and pigeons to a female Peregrine Falcon that was rearing a single fostered young after the death of the male. The young bird eventually fledged.

MANAGEMENT OF PERCHES

The use of artificial structures by perching raptors is as commonplace as the utility pole. Telephone poles, electric transmission towers, and electric distribution poles have altered the hunting strategies of dozens of species of raptors by opening up millions of acres of habitat to hunting from a stationary perch. The extent to which a new line is used was shown by Stahlecker (1978) in a "before-and-after" study along an electric transmission line in east-central Colorado. Use of pre-existing perches decreased and raptor densities increased significantly after the new line was built. Marion and Ryder (1975) found that Rough-legged Hawks (Buteo lagopus) and Prairie Falcons preferred high man-made perches, particularly electric distribution poles.

This preference for perching on power poles has also had negative effects on raptors, particularly the Golden Eagle, through electrocution, a problem which has been known for at least 40 years (Marshall 1940, Dickinson 1957). In the same area of northeastern Colorado that was studied by Marion and Ryder (1975), Olendorff (1972) reported that 17 Golden Eagles were found dead under 3 1/2 miles of powerlines. Other similar reports followed, both in North America (Smith and Murphy 1972, Laycock 1973, Boeker and Nickerson 1975) and abroad (Markus 1972, Garzon 1977).

This increased interest in raptor electrocutions stimulated a cooperative effort coordinated by Richard S. Thorsell of the Edison Electric Institute to address the problem. As a result, numerous federal agencies, conservation organizations, and private electric companies supported the development of "Suggested Practices for Raptor Protection on Powerlines" (Miller et al. 1975). This booklet includes numerous detailed specifications for eagle-safe powerlines, many of which were researched and developed by Morlan Nelson (Nelson and Nelson 1976, 1977; Nelson 1978). A recent symposium on raptors and energy development will update the status of this issue (Howard and Gore 1980).

The use of perches erected specifically for raptors has not been particularly successful. Steenhof (1977) reports that the U.S. Army Corps of Engineers erected four perch poles for Bald Eagles below Ft. Randall Dam, South Dakota. Bald Eagles were seen on them only two times in two years. Similar poor results have occurred in Oregon (Opp in Steenhof 1977). Biologists from the U.S. Bureau of Reclamation noted that the small nesting population of Bald Eagles in central Arizona was without hunting perches along extensive stretches of river. Twelve 40- to 60-foot poles were erected along the river in December 1976 (Stumpf 1977), but no followup is available.

Use of raptor perches to control rodent populations has received recent attention in California. Hall et al. (1978, 1979) proved that raptors would use their artificial perches, but could not relate perch use to decreases in rodent populations.

The U.S. Bureau of Land Management has funded two experimental perch-pole projects. Two poles erected near Saguache, Colorado, in large prairie dog towns have been used by Ferruginous Hawks, Red-tailed Hawks, Marsh Hawks (*Circus cyaneus*), and Golden Eagles (Snow 1974). Warburton (1972) erected eight artificial nesting/perching structures for large raptors in Puddle Valley, Utah, in 1972. The structures were frequently used as perches, and at least one unsuccessful nesting attempt by Golden Eagles occurred during the first two years, but long-term followup is unavailable.

Provision of Artificial Nests and Nesting Structures

Documentation of raptor nesting on man-made structures which were not intended for such purposes is beyond the scope of this paper. A general familiarity with this topic, which indicates the potential for raptors to use artificial structures erected specifically for them, can be gained from Herbert and Herbert (1965) and Hickey (1969) for Peregrine Falcons; Henny (1977b) for Ospreys; Gilmer and Wiehe (1977) for Ferruginous Hawks; and Olendorff and Stoddart (1974), Newton (1976), and Call (1979) for a variety of species.

Interest in artificial nests and nest structures specifically designed for raptors as a raptor habitat management technique was very high at the end of the 1970s (Table 3). Of 95 references to successes with artificial nests and nesting

Table 3.--Species of raptors that have used artificial nesting structures (i.e. structures designed and erected specifically for raptors) and artificial nests (nests built by man to look like natural nests).

Species	Reference	Nest Type
Osprey	Ames and Mersereau 1964	Platforms
	Bergman 1977	Artificial Nests
	Bogener 1979	Platforms
	Detrich 1978b	Platforms
	Garber et al. 1974	Platforms
	Henny et al. 1978a	Platforms
	Jacobs. 1977	Platforms
	Kahl 1972a, 1972b	Platforms
	Kennedy 1977b	Platforms
	Lee 1980	Platforms
	Nelson 1978	Platforms
	Persson (in Saurola 1978)	Artificial Nests
	Postupalsky 1978a	Platforms
	Postupalsky and Stackpole 1974	Platforms
	Reese 1965, 1970, 1977a, 1977b	Platforms
	Rhodes 1972, 1977	Platforms
	Saurola 1976, 1978	Artificial Nests
	Schey (in Saurola 1978)	Artificial Nests
	Sietke (in Saurola 1978)	Platforms
	Valentine 1967	Platforms
Honey-Buzzard (<u>Pernis apivorus</u>)	Rouhiainen et al. (in Saurola 1978)	Artificial Nests
Everglade Kite	Graham 1978	Wire Baskets
	Kern 1978	Wire Baskets
	Sykes and Chandler 1974	Wire Baskets
Bald Eagle	Dunstan and Borth 1970	Artificial Nests
	Grubb (in Call 1979)	Platforms
	Lamb and Barager 1978	Platforms
	Nelson 1978	Platforms
	Postupalsky 1978a, 1978b	Platforms
White-tailed Sea Eagle	Helander 1975, 1977	Artificial Nests
	Kulves (in Saurola 1978)	Platforms
European Sparrow-hawk	Saurola 1978	Artificial Nests
Northern Goshawk	Bijleveld 1974	Artificial Nests
	Persson (in Saurola 1978)	Artificial Nests
	Rouhiainen et al. (in Saurola 1978)	Artificial Nests
	Saurola 1978	Artificial Nests
		Artificial Nests

Table 3.--Continued.

Species	Reference	Nest Type
Swainson's Hawk	Fitzner 1980 pers. comm. (see text)	Platforms
	Fitzner 1980 pers. comm. (see text)	Artificial Nests
Red-tailed Hawk	Dunstan and Harrell 1973	Artificial Nests
	Henny et al. 1978a	Platforms
	Lee 1980	Platforms
	Nelson 1978	Platforms
	Nero et al. 1974	Artificial Nests
	Scott 1970, 1978	Platforms
Common Buzzard	Berggren 1975	Artificial Nests
	Persson (in Saurola 1978)	Artificial Nests
	Rouhiainen et al. (in Saurola 1978)	Artificial Nests
	Saurola 1978	Artificial Nests
Rough-legged Buzzard	Berggren 1975	Artificial Nests
	Saurola 1978	Artificial Nests
Ferruginous Hawk	Anderson (in Call 1979)	Platforms
	Call 1979	Wire Baskets
	Fyfe and Armbruster 1977	Wire Baskets
	Howard and Hilliard 1980	Platforms
Golden Eagle	Berggren 1975	Artificial Nests
	Call 1979	Wire Baskets
	Craig and Anderson (in Call 1979)	Platforms
	Kellomaki (in Bergman 1977)	Artificial Nests
	Nelson 1978	Platforms
	Nelson and Nelson 1977	Platforms
	Saurola 1978	Artificial Nests
	Warburton 1972	Platforms
American Kestrel	Bloom 1977, 1978	Nestboxes
	Clausager (in Saurola 1978)	Nestboxes
	Craig et al. 1979	Nestboxes
	Fitzner 1980 pers. comm. (see text)	Nestboxes
	Hamerstrom 1974	Nestboxes
	Hamerstrom et al. 1973	Nestboxes
	Heintzelman 1964, 1971	Nestboxes
	Heintzelman and Nagy 1968	Nestboxes
	Henderson and Holt 1962	Nestboxes
	Henny 1977a	Nestboxes
	Jones (in Byers 1980)	Nestboxes
	Nagy 1963	Nestboxes
	Stahlecker 1979	Nestboxes
	Stahlecker and Giese 1977	Nestboxes

Table 3.--Continued.

Species	Reference	Nest Type
Common Kestrel (<u>Falco tinnunculus</u>)	Bijleveld 1974 Cavé 1959, 1968 Hauri 1960 Kaeser 1957 Koning 1965 Krambrich 1968 Krambrich and Friess 1968 Saurola 1978 Schmidt 1948	Nestboxes Nestboxes Nestboxes Nestboxes Nestboxes Nestboxes Wicker (?) Baskets Nestboxes Nestboxes
European Hobby (<u>Falco subbuteo</u>)	Krambrich 1968 Saurola 1978	Wicker (?) Baskets Artificial Nests
Prairie Falcon	Boyce et al. 1980 Fyfe and Armbruster 1977	Artificial Nests Artificial Nests
Gyr Falcon	Schey (in Saurola 1978)	Artificial Nests
Peregrine Falcon	Cade and Dague 1979 Fyfe (in White 1974) Hall 1955 Mebis 1969	Artificial Nests Artificial Nests Artificial Nests Wicker Baskets
Barn Owl	Lenton 1978 Marti et al. 1979 Millsap (in Call 1979)	Nestboxes Nestboxes Nestboxes
Screech Owl (<u>Otus asio</u>)	Henderson and Holt 1962 VanCamp and Henny 1975 Wilson 1925	Nestboxes Nestboxes Nestboxes
Flammulated Owl (<u>Otus flammeolus</u>)	Bloom 1978	Nestboxes
Great Horned Owl	Berger 1956 Bohm 1977, 1980 Doty 1974 Dunstan and Harrell 1973 Postupalsky 1978a Scott 1970, 1976	Artificial Nests Wire Baskets Baskets Artificial Nests Platforms Platforms
Burrowing Owl (<u>Athene cunicularia</u>)	Collins and Landry 1977 Fitzner 1980 pers. comm. (see text) Orde (in Call 1979)	Nestboxes Artificial Nests Nestboxes
Tawny Owl (<u>Strix aluco</u>)	Delmee et al. 1978	Nestboxes

Table 3.--Continued.

Species	Reference	Nest Type
Great Gray Owl (<u>Strix nebulosa</u>)	Berggren 1975 Nero 1977 Nero et al. 1974 Persson (in Saurola 1978)	Artificial Nests Artificial Nests Artificial Nests Artificial Nests
Ural Owl (<u>Strix uralensis</u>)	Persson (in Saurola 1978) Rouhiainen et al. (in Saurola 1978)	Artificial Nests Artificial Nests
Saw-whet Owl (<u>Aegolius acadicus</u>)	Rever and Miller 1973	Nestboxes
Little Owl	Herren 1977 Knötzsch 1978	Nestboxes Nestboxes

structures, about 80 (i.e. 84 percent) report on separate projects. Seventy-six of the 95 references (80 percent) are from 1970 or later. Four main categories of artificial structures are discussed here: nestboxes, platforms, baskets, and artificial nests (i.e. nests carefully built by man to resemble natural nests).

NESTBOXES

The use of artificial nesting structures as research tools for studying the life histories, population dynamics, and contaminant loads of raptors is most refined with nestboxes. The most extensive study of this type was VanCamp's and Henny's (1975) work with Screech Owls in northern Ohio between 1944 and 1973. More than 4,249 nestboxes (as many as 985 in a single year) were checked during that 30-year period. As a result, the status, population dynamics, migration and dispersal patterns, breeding and wintering behavior, food habits, and pesticide loads of Screech Owls in that area are quite well-known.

The advantages of knowing the locations of nestboxes, the ease of checking them, and the long-term stability they provide to raptor populations have also been exploited by other researchers. Delmee et al. (1978) conducted a 15-year study of the population dynamics and breeding biology of Tawny Owls using artificial nest boxes. Some findings are difficult to obtain in any other way. For example, nest site and mate fidelity of Tawny Owls is nearly absolute (Delmee et al. 1978). The same is true of Screech Owls; one was banded at a box in 1945, retrapped there eight times through the years, and was killed within one-quarter mile of the box in 1958, thirteen years after being banded (VanCamp and Henny 1975).

Henny (1977a) set out about 300 nestboxes to attract nesting American Kestrels to an area sprayed with DDT, to an adjacent area, and to an unsprayed area during a controlled study of the effects of DDT and its residues on kestrel productivity.

Eggs were collected for pesticide analyses from 21 boxes in 1975 and from 51 boxes in 1976. (These figures also indicate the level of nestbox use.) It would have been very difficult to locate and monitor that many natural nests in the time available to Henny.

Using a similar research strategy, personnel of the Ecological Services Department of Battelle Pacific Northwest Laboratories (Battelle Boulevard, Richland, Washington 99352) put out 100 nestboxes in 1979 for small owls in coniferous forests as part of a long-term ecological monitoring program (Fitzner 1980 pers. comm.). Each nestbox is constructed so that when the owls are perched in the nest holes, all regurgitated pellets will fall onto a veranda to facilitate collection. Pellets will be collected and monitored for environmental contaminants. Craig et al. (1979) used 5 nestboxes to attract American Kestrels for the study of radionuclide concentrations in nestling raptors.

Other studies made possible by raptor use of nestboxes include the following. Nagy (1963) reported that six of nine nestboxes for American Kestrels were active in 1961 in an eastern Pennsylvania study area consisting of one-half square mile of farmland. Heintzelman (1964) reported on the summer food habits of this population. Heintzelman and Nagy (1968) reported on clutch sizes, egg hatchability, and sex ratios in 14 American Kestrel nesting attempts in nestboxes in the same area between 1959 and 1966 (the number of boxes available each year is not stated). Heintzelman (1971) also presented followup work suggesting that nestbox sanitation is not an important factor causing embryo mortality.

Hamerstrom et al. (1973) suspected that nest site availability was the limiting factor on American Kestrel populations in their harrier study areas in central Wisconsin where virtually no kestrel nesting had occurred prior to 1967. Of two nestboxes put up in 1967, one was used in 1967, and the other was used in 1968. Forty-eight more boxes were put up in 1968 and were maintained through 1972 (252 nestbox-years total). Kestrel activity was noted in 77 instances (31 percent) and 51 successful nests (20 percent) fledged 204 young.

In 1975 Stahlecker (1979) erected 25 nestboxes on wooden H-frame towers supporting a new electric transmission line crossing east-central Colorado. During 1975, 1976, and 1977 American Kestrel activity was noted at 12, 19, and 24 nestboxes, respectively (74 percent occupancy over 3 years), resulting in 172 young. Since only six natural kestrel nests occurred along the powerline route, this study clearly demonstrated the potential of nestbox construction as a mitigation measure along new powerlines. Henderson and Holt (1962) used nestboxes to facilitate their banding studies of Screech Owls and American Kestrels. Over a three-year period, 137 Screech Owls and 155 American Kestrels were banded in 200 nestboxes erected near Andover, Massachusetts.

The potential for use of nestboxes as a reclamation tool was shown by Cavé (1968) who in 1959 introduced 246 nestboxes into an area recently reclaimed from the sea in the Netherlands. The next year 109 pairs of Common Kestrels nested in the area. The same potential exists where strip mines or other areas with severe surface disturbance are reclaimed.

The frequent use of nestboxes in European countries to bolster Common Kestrel populations was reviewed by Saurola (1978). Denmark, Switzerland, Great Britain, the Netherlands, Germany, and many other countries have kestrel nestbox programs--some have been operating for up to 30 years! While most raptor nestbox programs in North America have been conducted to meet various research goals, nestboxes could be installed on a large scale with significant results whenever desirable. Bloom

(1977, 1978) lists as goals of a nestbox program the expansion of nesting habitat where no habitat presently exists and the reestablishment of such habitat where it has been eliminated. During the fall of 1976, Bloom erected 100 nestboxes in several habitat types in northeastern California. Of 67 useable boxes in 1977, fourteen (21 percent) were used by American Kestrels. Only 54 boxes were useable in 1978, but 18 of these (33 percent) were used by American Kestrels, and another housed a pair of Flammulated Owls.

Nestboxes have also been the standard nesting situation offered to captive kestrels to stimulate breeding (e.g., Willoughby and Cade 1964, Koehler 1969, Porter and Wiemeyer 1970, and Bird et al. 1976). Details concerning kestrel nestbox dimensions and construction can be found in Ross (1969) and Byers (1980).

Besides Delmee et al. (1978) on Tawny Owls and VanCamp and Henny (1975) on Screech Owls, three other nestbox studies involving owls are noteworthy. Lenton (1978) reports considerable initial success with conditioning Barn Owls to use large artificial nest boxes atop 24-foot wooden poles. Although this program was only one or two years old at the time, 7 of 30 boxes were in use. Marti et al. (1979) installed eight large nestboxes in 1977 and an additional 22 in 1978 in abandoned grain silos in northern Utah where Barn Owls had been roosting. Four of the eight available boxes were used by nesting Barn Owls in 1977. Twenty-four of the 30 boxes available in 1978 were used. Out of a total of 38 nestbox-years, 28 (74 percent) were occupied.

Artificial nestboxes buried in the ground are also readily adopted by Burrowing Owls. Collins and Landry (1977) built 30 nest chambers and burrows connecting to the outside and covered them with at least 6 inches of dirt in Orange County, California. The easily opened chamber provided ready access for growth and life history studies. Twenty of the 30 chambers (67 percent) were in use in 1975. Orde (in Call 1979) is experimenting with similar structures on the Pawnee National Grassland in northeastern Colorado. Since destruction of burrows is a primary cause of Burrowing Owl declines, and because these owls can live in concert with man if left alone, this technique indicates great potential 1) for promoting Burrowing Owl nesting in and adjacent to urban areas and 2) as a reclamation tool wherever needed.

Artificial Platforms

The most successful artificial platform programs are for Ospreys. Hundreds of structures have been erected for this species, often as a logical extension of the Osprey's ready acceptance of man-made nest substrates placed in their habitats for other purposes (e.g., channel markers, duck blinds, piles of crab traps, utility poles, docks, and pilings).

The earliest available reference to erecting artificial nesting platforms for Ospreys is Ames and Mersereau (1964). They erected three platforms in 1961 in southern Connecticut after most pairs had already chosen nest sites. Nonetheless, all three sites were immediately occupied, and in two cases eggs were laid within 72 hours. Twenty-one nesting platforms were erected in the same area in 1962 with the aid of a grant from the National Geographic Society (Peterson 1969). Nine of these were active in 1962, and 11 were active in 1963 for a total of 45 platform-years in the area and a 51 percent occupancy rate. Ames and Mersereau (1964) concluded that the platforms effectively protected the birds from predation and tidal flooding, but productivity of the entire population remained extremely low due to pesticide contamination (0.29 young per nesting for 157 nestings over four years).

In 1964 Reese (1965, 1970, 1977a, 1977b) began erecting artificial platforms for Ospreys along the coast of Chesapeake Bay in Maryland. Between 1964 and 1974 a total of 285 platform-years (mean = 26 platforms per year) were available to Ospreys. Birds used 164 (58 percent) of these (Reese 1977b), an occupancy rate close to that obtained by Ames and Mersereau (1964).

Another successful artificial platform program for Ospreys in Michigan began in 1967 (Postupalsky 1978a, Postupalsky and Stackpole 1974). Between 1967 and 1977, 425 platform-years were available. The rate of occupancy was 55 percent (233 out of 425). The eleven-year means for productivity in natural nests versus artificial platforms were 0.6 and 1.2 large or fledged young per occupied nest, respectively. At one site, Fletcher Pond, the Osprey population was decreasing due to deterioration of existing nest sites, primarily snags resulting from the original man-created flooding. From a low of 11 pairs in 1966 this population increased to and stabilized at about 17 pairs by 1972, after 20 platforms were constructed in 1967. The platforms not only reversed a declining population trend, but also maximized productivity by reducing nestling loss due to nest blowdowns.

Equally encouraging results were obtained by Rhodes (1972, 1977) on the Glen L. Martin National Wildlife Refuge in Maryland between 1968 and 1972. The Osprey population on the refuge increased from four to six pairs before 1968 to 18 to 20 pairs in 1971 and 1972. The occupancy rate of artificial structures over the five-year period was 78 percent (75 nestings out of 96 platform-years), but productivity was less on the platforms (1.4 young per active nest) than at "natural" nest sites (2.0 young per active nest).

Two other large and long-term Osprey platform projects have been very successful but await quantitative analysis of results. In 1971 at the Eagle Lake Osprey Management Area (California) 15 live pine trees were topped. Spikes driven in around the circumference of the cuts provided stability for prospective nests. In addition, 20 artificial platforms supported by huge cedar poles were erected in the management area (Kahl 1972a, 1972b; Garber et al. 1974). One year later Ospreys used 12 of the 20 artificial structures (69 percent occupancy), but only one of the 15 topped trees. Henny et al. (1978a) reported 13 pairs of Ospreys using platforms at the Crane Prairie Osprey Management Area in Oregon, but no other follow-up on this project, which began in 1969 (Roberts 1969, 1970), was available for this review. The U.S. Forest Service could make a significant contribution to the raptor management literature by analyzing and publishing the data from their two Osprey Management Areas.

Kennedy (1977b) erected 20 platforms on the eastern and western shores of Chesapeake Bay in Virginia. Ten (50 percent) were active the year after they were erected. Sietke (in Saurola 1978) reported that nearly all of 25-30 platforms erected on powerline poles in Germany are used by Ospreys each year.

Fifteen platforms on Shasta Lake (California) had an occupancy rate of only 11 percent from 1977-1979 (five nestings in 45 platform-years) (Bogener 1979). In 1979 most of the limbs near these platforms were trimmed away at the suggestion of Detrich (1978b) in an effort to increase the occupancy rate. References to other smaller or unquantifiable Osprey artificial nesting platform projects are listed in Table 3.

Nesting on man-made structures by Bald Eagles is extremely rare. Abbott (1978) reported that two pairs of Bald Eagles nested on 100-foot high wooden observation towers at the U.S. Army Proving Grounds at Aberdeen, Hartford County,

Maryland, during the late 1950s and early 1960s. Postupalsky (1978a) cited two other such instances in the northeastern United States (Langille 1884) and in Alaska (Sherrod et al. 1976).

Similarly, only a few Bald Eagles have used artificial nest structures. Postupalsky (1978a, 1978b, 1980 pers. comm.) has witnessed nine nesting attempts on three different artificial structures through the 1979 nesting season. The first and only successes were in Michigan in 1977. One pair nesting on an Osprey platform in the Upper Peninsula fledged two young. Another pair fledged three young from a makeshift wooden pallet platform erected near Fletcher Pond to replace a fallen nest in 1969. Nelson (1978) reports a pair of Bald Eagles at one of his Golden Eagle platforms (see below) in 1977, but a nest was not built. The U.S. Forest Service has erected several platforms for Bald Eagles at Ruth Lake, Trinity County, California, according to specifications developed by Lamb and Barager (1978), but it is too early to evaluate the success of this project. Grubb (in Call 1979) built two tripod-type structures for Bald Eagles in Arizona. One was used the first spring that it was available, but the nesting attempt was unsuccessful.

Kulves (in Saurola 1978) reported that 20 platforms were erected for White-tailed Sea Eagles in Finland during the mid-1970s, but none had been used by 1977. Use of artificial nests (i.e. those carefully built to resemble natural nests) by Bald Eagles and the closely related White-tailed Sea Eagle is discussed elsewhere.

Another species that frequently nests on man-made structures not designed for that purpose (e.g., power poles, windmills, haystacks, stone chimneys of abandoned buildings, shepherd monuments, etc.) is the Ferruginous Hawk. Perhaps the best designed raptor management research project involves the installation in late 1975 of 12 pairs of platforms for this species in an area near the Snake River Birds of Prey Natural Area in Idaho where no Ferruginous Hawks nested previously (Howard and Hilliard 1980). Each pair of structures consisted of one with a sun shade and one without about 150 yards from each other. Thus, 12 territories with artificial platforms were available from 1976 through 1979 (48 platform-years). Seven nestings by Ferruginous Hawks occurred during that time (15 percent occupancy), five of which were successful. In addition, ten nestings of Ravens (Corvus corax) occurred, eight of which were successful. The occupancy rate for Ferruginous Hawks and Ravens combined was 35 percent. No Ferruginous Hawks nested on the shaded structures, although Ravens did so readily.

Probably the most experience with Ferruginous Hawk artificial structures of various types has been gathered since 1968 by William Anderson of La Junta, Colorado, and Gerald R. Craig of the Colorado Division of Wildlife. Several artificial platforms have been erected on the Pawnee and Comanche National Grasslands, and many artificial nests (see below) have been installed both in new territories and where long-standing nest sites have fallen naturally. At the 1978 annual meeting of the Raptor Research Foundation, Anderson reported that on the southern half of the Comanche National Grassland the number of nesting Ferruginous Hawks had increased from 7 to 15 pairs, and productivity had increased from 1.8 to 3.1 young per nesting attempt. A definitive publication of the results of this program would be a welcome addition to the literature on raptor management.

Two other buteos have been known to use artificial platforms. Fitzner (1980 pers. comm.) reported that a farmer northeast of Connell, Washington, placed several telephone poles with shallow vegetable crates on top into dryland wheat fields hoping to attract nesting raptors. No nesting occurred on these structures for at least a decade. However, one crate put up on a defunct windmill has been used for

several years by a pair of Swainson's Hawks. In 1975 Stahlecker (1979) erected 12 platforms on a new double crossbar H-design powerline in Colorado expecting use by prairie buteos. No raptors used the platforms during 1975, 1976, or 1977, but one pair of Ferruginous Hawks and one pair of Swainson's Hawks nested on the double crossbars.

Red-tailed Hawks have used artificial platforms installed for Golden Eagles in Idaho and Oregon by Nelson (1978) and Lee (1980) and for Ospreys at the Crane Prairie Osprey Management Area in Oregon (Henny et al. 1978a).

Artificial platform use by Golden Eagles is uncommon, but several instances are noteworthy. Call (1979) reports a successful nesting by Golden Eagles on the Pawnee National Grassland in northeastern Colorado, and Warburton (1972) reports at least one unsuccessful attempt on a platform in Puddle Valley, Utah.

The most significant developmental work on Golden Eagle nest structures has been done by Morlan Nelson of Boise, Idaho, as part of his consultant work with the electric industry (Nelson 1978, Nelson and Nelson 1977). He began testing the use of artificial nesting platforms for Golden Eagles in 1975. Noting that several species of birds, including Golden Eagles, Ospreys, Red-tailed Hawks, Ferruginous Hawks, and Ravens, were using steel and wooden transmission line towers for nesting, he reasoned that well-constructed nesting platforms on the towers would provide the needed nesting sites and lessen the chance of power outages that could result from nesting materials.

Working with the Bonneville Power Administration and the Idaho Power Company, Nelson erected six platforms prior to the 1977 nesting season on lines carrying up to 720,000 volts. All platforms were between 75 and 175 feet above the ground. On the six nesting platforms installed, five nesting attempts were made. Three were successful (for a Red-tailed Hawk, Golden Eagle, and Osprey), while two were unsuccessful (for an Osprey and a Bald Eagle).

Nelson (1978) emphasized the importance of shade and protection from the wind in exposed sites. In hot desert areas, young Golden Eagles, Red-tailed Hawks, and Prairie Falcons may die from overheating if shade is not available for at least the head and shoulders. Shelter from the wind also appears to be beneficial to Golden Eagles and Red-tailed Hawks, but Ferruginous Hawks and Ospreys seem to have no requirement for protection from either the sun or the wind. This work is discussed further by Lee (1980). It has recently reached the implementation stage in Idaho and Oregon where 40 platforms are being erected on a new electric transmission line as an enhancement measure (Nelson 1980 pers. comm.).

The only other raptor for which use of artificial platforms is documented is the Great Horned Owl. Postupalsky (1978a) reports two nestings of Great Horned Owls on his tripod-type Osprey platforms in Michigan. Scott (1970, 1976) has attracted several pairs of Great Horned Owls to artificial platforms (actually shallow boxes).

BASKETS

Occasionally the distinction between artificial platforms and nesting baskets is difficult to make. For example, the duck nesting baskets monitored by Doty (1974), which have been used at least twice by Great Horned Owls, appear much like low platforms. Bohm (1977, 1980) had good acceptance of nest baskets by Great Horned Owls in central Minnesota. The nests were made of one-inch mesh chicken wire formed into a shallow cone. The cone was then lined with tar paper and provided

with a drainage hole at the base. An artificial nest consisting of twigs, leaves, and branches, with finer material near the top where the eggs would be laid, was built in each basket. Once the entire nest was complete, it was attached in a suitable crotch of a tree. Of 27 such nests available in 1977, 14 were used by Great Horned Owls and one was used by Red-tailed Hawks (combined occupancy rate of 56 percent). Productivity was slightly lower in baskets compared to natural nests.

A similar technique has worked well for Ferruginous Hawks. Call (1979) installed three wire baskets for Ferruginous Hawks in 1979 on the Pawnee National Grassland. Two of the three were used the same year. Fyfe and Armbruster (1977) reported that a major limiting factor for some raptors in Alberta appeared to be the lack of nest trees. Thus, in 1971 the Canadian Wildlife Service constructed and erected artificial wire baskets for Ferruginous Hawks in five areas where old sites had been destroyed (Fyfe 1975). Four of these were occupied in 1972. By 1975, 37 baskets had been erected, of which 22 were erected in former raptor territories and 15 were placed in grassland areas with adequate prey but no previous record of occupancy. Of the 37 baskets, a total of 16 (43 percent) had been occupied by 1975, indicating the effectiveness of this technique. The majority of the occupancy was in former territories, indicating that these should receive first priority for artificial nest structures (Fyfe and Armbruster 1977).

Wire baskets are also used to stabilize the rather flimsy nests of Everglade Kites in Florida (Sykes and Chandler 1974, Graham 1978, Kern 1978). It is interesting that most attempts to get this species to use the baskets are accomplished after natural nests are built and eggs are laid or young are present. Nests and eggs or young are simply moved from their original settings short distances into the baskets with near total success.

Wicker baskets have been used in at least two areas in Europe with success reported for three species. The most significant project was the placement of 15 willow baskets mostly in old pine trees in northern Germany for tree nesting Peregrine Falcons during the 1950s. Five or six of the baskets were used, as were at least four deer shooting platforms built in trees in the same general area. Krambrich and Friess (1968) report that pairs of European Hobbies and Common Kestrels have used baskets (presumably wicker) placed in trees for crows.

ARTIFICIAL NESTS

Nest sites developed by man to closely resemble natural nest sites are termed artificial nests in this review paper. The construction of artificial nests is much more common in Europe than in North America. Americans seem especially willing to place unnatural nestboxes, platforms, and baskets in the environment, a tendency that is arguable philosophically and worthy of full consideration as raptor management projects become less research oriented and designed more for widespread implementation.

Many artificial nests have been constructed as emergency measures after nests have blown down, either to save nestlings from the same year or to keep a territory active in subsequent years. For example, Dunstan and Borth (1970) reconstructed an active Bald Eagle nest that had blown down, thereby allowing two nestlings to fledge naturally. During the fall of 1969 a broken Red-tailed Hawk nest was rebuilt by Dunstan and Harrell (1973). Red-tailed Hawks used it in 1970, and Great Horned Owls fledged young from it in 1971. In 1976 Fitzner (1980 pers. comm.) fabricated stable bases for two Swainson's Hawk nests which frequently blew down. In each case a three-pronged crotch of a downed tree was supplemented with other sticks by tying

them on with bailing wire. The crotch was then wired into the nest tree. One of the two sites was used in 1978 and 1979. Craig and Anderson (in Call 1979) reconstructed a Golden Eagle nest that was blown down one year and was idle the following summer. Nesting resumed the year after the artificial nest was built.

Although some artificial nests might also be classified as nesting platforms, the intent in each of the following cases was to construct as natural a situation as possible. Haugh and Halperin (1976) report that artificial wooden ledges placed along the sloping banks of the Sagavanirktok River in Alaska have not been used by Peregrines or Gyrfalcons. Schey (in Saurola 1978) described the construction of an artificial nest for Gyrfalcons which was in use the summer after it was built. Hall (1955) and Cade and Dague (1979) provided shallow boxes filled with sand and gravel to Peregrine Falcons nesting on large buildings, primarily to provide the proper substrate for nest scraping. Boyce et al. (1980) replaced an abandoned Peregrine Falcon nesting ledge in northern California after it had fallen from the cliff. The steel ledge took 4 days to fabricate and install, but the natural-looking result was utilized the following summer by a pair of Prairie Falcons which fledged two young. In December 1979 William E. Lehman and Douglas A. Boyce excavated a ledge on a cliff in Humboldt County, California, which had been rated as a potential Peregrine site. A female Peregrine was observed incubating eggs on the new ledge in April 1980, four months after its excavation (Boyce 1980 pers. comm.).

One of the largest artificial nest construction programs involves Prairie Falcons along several rivers in Alberta. Fyfe and Armbruster (1977) describe the digging of nesting cavities for Prairie Falcons into cliffs that previously had few or no suitable nesting holes. This problem has also been noted in Colorado (Olen-dorff and Stoddart 1974) and in Washington State (Olendorff 1973).

In 1970 four of five nest holes dug for Prairie Falcons in Alberta were occupied by pairs; the fifth was used by a lone male (Fyfe and Armbruster 1977). The next year 8 of 12 holes were used by either Prairie Falcons or Canada Geese (Branta canadensis), the other target species of the program. Between 1971 and 1975 field crews from the Canadian Wildlife Service and the Saskatchewan Falconry Association dug over 200 nesting holes, about one-quarter of which were occupied during that period, occasionally even by Peregrine Falcons (White 1974). This program has been so extensive that systematic follow-up has been impractical.

In 1976 Fitzner (1980 pers. comm.) accomplished a similar result (though on a smaller scale) with Burrowing Owls in south-central Washington State. He dug seven burrows into sandy loam banks along intermittent streams. Each hole was dug 3 1/2 to 4 feet deep with a shovel, about halfway up 10- to 15-foot banks. Four of the seven burrows were utilized by owls the first year, but there has been no follow-up since that time.

A large-scale and long-term artificial nest program for Great Gray Owls has been conducted since 1970 in southern Manitoba and northern Minnesota (Nero et al. 1974, Nero 1977). About 60 artificial nests, which are barely discernable from natural ones, are currently checked and maintained each year. Unfortunately, neither of the papers cited above indicates how many of these nests are active each year, but Great Gray Owls and an occasional pair of Red-tailed Hawks have used them.

The Great Gray Owl has also received considerable attention in Europe. Persson (in Saurola 1978) has the most extensive program with approximately 100 artificial nests built since about 1972 in Sweden. Another 50 to 100 such nests have been built by others in the same area. Several raptors besides Great Gray Owls have also used these nests, including Common Buzzards, Goshawks, Ospreys, and Ural Owls.

Berggren (1975) documented the nesting of Rough-legged Hawks and Golden Eagles on artificial nests in Sweden. Also in Sweden, Helander (1975) documents three such nestings of White-tailed Sea Eagles.

Finnish ornithologists are also very active in building artificial nests of two types. Artificial Osprey nests (120 are now in place) closely resemble platforms, but they are built atop trees and are made to look like natural nests (Saurola 1978). Nests for Common Buzzards, Honey Buzzards, Goshawks, and Ural Owls are usually constructed of small sticks woven into the existing structure of branches to form a stable base. No wire, nails, or other man-made materials are used. The base is then topped with a nest built of naturally occurring vegetation (Rouhiainen et al. in Saurola 1978). Between 1975 and 1977, 239 artificial nests were available in the Paijat-Hame, Finland, study area. Sixty-five of these (i.e. 27 percent) were used by four species of large raptors (see above).

CLOSING REMARKS

Time constraints have prevented discussion in this paper of the appropriateness of each raptor conservation method. A number of publications do discuss the theoretical and philosophical aspects of raptor management. The more important of these found in the raptor literature or closely allied publications are mentioned below. However, an exhaustive search of the total ornithological and wildlife management literature for theories and philosophies which may apply to raptor management was not possible.

The general approaches to raptor management have been discussed by Nelson (1969a), Cade (1971, 1974b), Olendorff and Stoddart (1974), White (1974), Hamerstrom (1974), and Mallette and Gould (1976). Ratcliffe (1977) divides these approaches into three classifications.

The first involves controlling people and, of course, minimizing impacts. Fyfe and Olendorff (1976) discuss ways to minimize the direct impacts of man's individual activities on raptors. Newton (1979) gives an excellent review of the effects of human persecution on raptors. Others have begun direct research on thresholds of disturbance tolerated by raptors (White et al. 1979). These thresholds must be known before serious behavior modification programs (as discussed by Temple 1978c) can be researched and implemented for raptors. These thresholds also affect the choice between active and passive conservation of raptors (i.e. protection versus management) (see King 1978). Related discussion of the philosophies of total protection versus management of Peregrine Falcons is offered by Cade (1971, 1974b).

Ratcliffe's second classification of the approaches to raptor management is similar to the concept of habitat management set forth in the present paper. Habitat destruction is one of the "ultimate" causes of raptor declines, as opposed to "proximate" causes, such as shooting and electrocutions (see Temple 1978a). Ultimate causes of declines often affect factors that already may be limiting to raptor populations, primarily food supply and nest site availability. Snyder and Snyder (1975) and Newton (1976, 1978) discuss the importance of knowing the limiting factors prior to conducting raptor management programs. Others have discussed in more general terms the information needed to manage raptor populations (e.g., Fuller et al. 1974, Olendorff and Stoddart 1974, Ratcliffe 1977).

Ratcliffe's third category of management is controlling the birds themselves (i.e. species management as presented in this paper). It is important to answer the

question, "What species do we want to manage for?" It is too easy to make fundamental errors, because what is good for one species may be devastating to another. We could easily promote the abundance of a certain raptor and thereby depress the faunal diversity of an area (see Snyder and Snyder 1975). Thus we must make plans and set goals (Ratcliffe 1977), not unlike those in many of the recovery plans for endangered species (Marshall 1978) or in California's statewide plan for raptor conservation (Mallette and Schlorff 1978), an approach that other States and countries should emulate.

It is only through complete, integrated approaches as discussed by Plunkett (1978) that we will achieve the best results. This has been said in many ways before. Olendorff and Stoddart (1974) call for a multi-faceted, penetrating research effort to synthesize quantitative data concerning raptor population dynamics, ecological impacts, management, and conservation. Galushin (1977) put it this way: "if man's influence on birds of prey is multi-factorial, a policy to protect them from extinction should also be multi-directional."

Examples of integrated management for birds of prey are becoming more commonplace as raptor conservation becomes more popular. The endangered species of the world are the greatest benefactors of such management (Plunkett 1978). Currently in the United States there are recovery teams for the California Condor, Bald Eagle (5 regional teams), Peregrine Falcon (4 regional teams), and Everglade Kite. Recovery plans are approved for the California Condor and two Peregrine Falcon populations (Eastern and Rocky Mountain (Southwest)). Draft plans from most other recovery teams for endangered raptors are in various stages of review.

Less formal but still excellent examples of integrated raptor management programs can be found as follows: for the Osprey--Gale and Forkis 1974, Garber et al. 1974, Henny 1977, Kahl 1971, Roberts 1969; for the Bald Eagle--Beebe 1976, Robards and Taylor No Date; for the White-tailed Sea Eagle--Helander 1975, 1977; for the Mauritius Kestrel--Temple 1977; for the Peregrine Falcon--Armbruster 1978, Burnham 1979, Cade and Temple 1977, Fyfe and Armbruster 1977, Lindberg 1975, 1977, Monneret 1978, Walton 1979a, 1979b; for the Eagle Owl--Broo 1977, 1978, Wayre 1970, 1975; and for various species--Chaney 1979, Mallette and Schlorff 1978, Olendorff and Kochert 1977, Olendorff and Zeedyk 1978, U.S. Bureau of Land Management 1979. Nearly all other projects involve narrower, single-method approaches to raptor conservation which collectively contribute significantly to the more integrated management programs.

It is readily apparent from the raptor management literature of the 1970s that the next decade will be another of tremendous progress. Three lines of thought outlined by Voous (1977) at the 1975 World Conference on Birds of Prey are still appropriate for action in the 1980s. First, birds of prey are naturally-provided and cheap biometers--indeed computers!--of the collective impacts, both positive and negative, of ecologically disruptive activities. This concept was presented very succinctly by Curry-Lindahl (1977). He stated that "...raptorial birds as the last links of food chains become important as indicators of well-balanced ecosystems, of landscape health and of environmental quality." Unfortunately, we have not quantitatively illustrated through basic research the practical applications (other than pesticide monitoring) of the concept of using birds of prey as indicators of the long-terms collective impacts of the many other major degrading environmental factors. This concept has both species and habitat management aspects that should be researched during the 1980s.

This will require the establishment of baseline population data, even where raptors are abundant. Voous (1977) suggests, as his second item for eventual action, that we should not just preserve the habitats of rare, threatened, or endangered raptors. An ecosystem approach is recommended, including the protection of at least one nature reserve in each ecosystem where raptors still occur in large numbers and diversity. A common thread in the raptor conservation literature is that habitat protection may be the best way to save raptors in perpetuity, a concept that must be woven into the very fabric of raptor management during the 1980s. There are many exemplary habitats which, like the Snake River Birds of Prey Natural Area, need protection and management.

Finally, there are smaller areas where birds of prey should be kept in and man should be kept out (Voous 1977). Such places may not harbor all of the components of a representative ecosystem, but they have unusually high raptor populations. Management areas, sanctuaries, and buffer zones strengthened by land acquisitions, administrative closures, and other available techniques should become the hallmark of integrated raptor conservation programs during the 1980s. Perhaps in this way we can minimize the use of captive breeding, artificial structures, artificial feeding, behavior modification, hacking, cross-fostering, egg manipulations, and surveillance to keep raptor populations at levels necessary to prevent their further endangerment and subsequent extinction. Nonetheless, we must stand ready with a complete repertoire of fully researched management techniques with which to tinker and save species.

ACKNOWLEDGEMENTS

The authors wish to acknowledge the assistance of Amy Heuslein in developing the reference and data card files on which this paper is based. Hollie Schroeder and Anne Russell operated the word processors. Their professional efforts and positive attitudes made it possible to attend to the writing and editing detail necessary to produce such a lengthy review paper. Virginia Schoeffler and Tonni Woodward also did an excellent job on the graphics (Figures 1 and 2). The authors also wish to express appreciation to the Bureau of Land Management for encouraging our pursuit of professional goals within our area of specialized expertise.

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